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ST. LAWRENCE WATERWAY

MESSAGE

FROM THE

PRESIDENT OF THE UNITED STATES

TRANSMITTING

A LETTER FROM THE SECRETARY OF STATE SUBMITTING THE REPORT OF THE INTERNATIONAL JOINT COMMISSION CONCERNING THE IMPROVEMENT OF THE ST. LAWRENCE RIVER BETWEEN MONTREAL AND LAKE ONTARIO FOR NAVIGATION AND POWER

...ANUARY 16, 1922.—Referred to the Committee on Foreign Relations

WASHINGTON
GOVERNMENT PRINTING OFFICE
1922

67TH CONGRESS
2d Session

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SENATE RESOLUTION NO. 215.

SUBMITTED BY MR. KELLOGG.

IN THE SENATE OF THE UNITED STATES,
January 18, 1922.

Resolved, That the message from the President of the United States, transmitting a letter from the Secretary of State, submitting the report of the International Joint Commission on its investigation concerning the improvement of the St. Lawrence River between Montreal and Lake Erie for navigation and power, laid before the Senate and referred to the Committee on Foreign Relations on January 16, 1922, be printed with all accompanying papers and illustrations as a Senate document.

Attest:

GEORGE A. SANDERSON,
Secretary.

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INTERNATIONAL JOINT COMMISSION.

WASHINGTON—OTTAWA.

UNITED STATES.
OBADIAH GARDNER, *Chairman.*
CLARENCE D. CLARK.
MARCUS A. SMITH.
WILLIAM H. SMITH, *Secretary.*

CANADA.
CHARLES A. MAGRATH, *Chairman.*
HENRY A. POWELL, K. C.
SIR WILLIAM HEARST, K. C. M. G.
LAWRENCE J. BURPEE, *Secretary.*

LETTER OF TRANSMITTAL.

To the Senate and House of Representatives:

By section 9 of an act entitled "An act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," approved March 2, 1919, the Congress expressed a desire that the International Joint Commission investigate what further improvement of the St. Lawrence River between Montreal and Lake Ontario is necessary to make the river navigable for ocean-going vessels, together with the estimated cost thereof.

Under date of January 21, 1920, the Governments of the United States and Canada, by agreement, referred the matter to the International Joint Commission, pursuant to the provisions of Article IX of the treaty relating to the boundary waters between the United States and Canada, signed by the United States and Great Britain on January 11, 1909.

I transmit herewith, for the information of the Congress and for such action as it may deem appropriate, a report, bearing date of December 19, 1921, submitted to the Department of State by a letter of the joint secretaries of the commission, dated January 6, 1922, presenting the findings, conclusions, and recommendations of the commission regarding the matter.

WARREN G. HARDING.

THE WHITE HOUSE,
January 16, 1922.

LETTERS OF SUBMITTAL.

The PRESIDENT:

I have the honor to submit herewith for your consideration and for transmission to the Senate and House of Representatives, if that procedure have your approval, copies in duplicate of the report of the International Joint Commission on its investigation concerning the improvement of the St. Lawrence River between Montreal and Lake Ontario for navigation and power.

By section 9 of an act entitled "An act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," approved March 2, 1919, the Congress expressed a desire that the International Joint Commission investigate what further improvement of the St. Lawrence River between Montreal and Lake Ontario is necessary to make the river navigable for ocean-going vessels, together with the estimated cost thereof.

The report which I herewith submit, bearing date of December 19, 1921, submitted to the Department of State by a letter of the joint secretaries of the commission, dated January 6, 1922, presents the findings, conclusions, and recommendations of the commission on a reference of the matter to it under date of January 21, 1920, by agreement of the Governments of the United States and Canada under the provisions of Article IX of the treaty relating to the boundary waters between the United States and Canada, signed by the United States and Great Britain on January 11, 1909.

Respectfully submitted.

CHARLES E. HUGHES.

DEPARTMENT OF STATE,
Washington, January 14, 1922.

INTERNATIONAL JOINT COMMISSION,
Washington, D. C., January 6, 1922.

SIR: We have the honor to transmit herewith the report of the International Joint Commission in the matter of the St. Lawrence River navigation and power investigation, referred to the commission on January 21, 1920, under the provisions of Article IX of the treaty of January 11, 1909, between the United States and Great Britain.

We have the honor to be, sir,
Your obedient servants,

WM. H. SMITH,
LAWRENCE J. BURPEE,
Joint Secretaries.

The SECRETARY OF STATE,
Washington, D. C.

REPORT ON THE ST. LAWRENCE NAVIGATION AND POWER INVESTIGATION, 1921.

PART I.

INTRODUCTION.

On the 21st of January, 1920, the Governments of the United States and Canada referred to this commission for investigation and report, under the terms of article 9 of the treaty of January 11, 1909, certain questions relating to the improvement of the St. Lawrence River between Lake Ontario and Montreal for navigation and power. These questions are set forth in the official reference, the terms of which are as follows:

TEXT OF REFERENCE.

I have the honor to inform you that the Governments of the United States of America and of the Dominion of Canada, under the provisions of article 9 of the treaty of the 11th of January, 1909, between the Governments of the United States and Great Britain, herewith refer certain questions, as set forth below, involving the beneficial use of the waters of the St. Lawrence River between Montreal and Lake Ontario, in the interests of both countries, and, in general, the rights, obligations, or interests of either in relation to the other, or to the inhabitants of the other along their common frontier.

It is desired that the said questions be made the basis of an investigation to be carried out by the International Joint Commission, to the end that the said commission may submit a report to the two countries covering the subject matter of this reference, together with such conclusions and recommendations as may be considered pertinent in the premises.

Question I. What further improvement in the St. Lawrence River, between Montreal and Lake Ontario, is necessary to make the same navigable for deep-draft vessels of either the lake or ocean-going type; what draft of water is recommended; and what is the estimated cost?

In answering this question the commission is requested to consider:

(*a*) Navigation interests alone, whether by the construction of locks and dams in the river; by side canals with the necessary locks; or by a combination of the two.

(*b*) The combination of navigation and power interests to obtain the greatest beneficial use of the waters of the river.

Question II. Which of the schemes submitted by the Government or other engineers is preferred, and why?

Question III. Under what general method of procedure and in what general order shall the various physical and administrative features of the improvement be carried out?

Question IV. Upon what basis shall the capital cost of the completed improvement be apportioned to each country?

Question V. Upon what basis shall the costs of operation and maintenance be apportioned to each country?

Question VI. What method of control is recommended for the operation o the improved waterway to secure its most beneficial use?

Question VII. Will regulating Lake Ontario increase the low-water flow i the St. Lawrence Ship Channel below Montreal? And if so, to what exten and at what additional cost?

Question VIII. To what extent will the improvement develop the resources commerce, and industry of each country?

Question IX. What traffic, both incoming and outgoing, in kind and quantity is likely to be carried upon the proposed route both at its inception and in th future, consideration to be given not only to present conditions, but to prob able changes therein resulting from the development of industrial activities du to availability of large quantities of hydraulic power?

Pending the receipt of plans, estimates, and other engineering data necessar for the final consideration of this reference, the commission is requested to hol such public hearings as may be considered necessary or advisable in order t obtain all information bearing, directly or indirectly, on the physical, com mercial, and economic feasibility of the project as a whole.

To facilitate the preparation of the desired report each Government will, fro its official engineering personnel, appoint an engineer with full authority t confer with a similar officer of the other Government for the purposes, first, o acquiring, each in his own country, such data as may be found necessary to sup plement the existing engineering data and surveys and, second, of preparin complete outline plans for and estimates of the cost of the proposed improve ment, including the value of all property, easements, damages, and rights con nected therewith. These plans and estimates are to be submitted to the com mission as soon as practicable but not later than one year from the date o appointment and the commission is requested to forward to the two Govern ments its final report with recommendations not later than three months there after. A copy of the instructions furnished these engineers is attached hereto.

INSTRUCTIONS TO ENGINEERS.

Attached to the reference, for the information of the commission is the following letter of instruction to the board of engineers create by the two Governments to report to the commission on the engineer ing features of the proposed improvement:

You are hereby designated to take charge of the survey of the St. Lawrenc River, Montreal to Lake Ontario, for the purpose of preparing plans and esti mates for its further improvement to make the same navigable for deep-draf vessels of either the lake or ocean-going type, and to obtain the greatest bene ficial use from these waters.

The surveys, plans, and estimates are to be submitted to the Internationa Joint Commission within 12 months and are to assist the commission in answer ing the questions of a reference to the matter under the provisions of article 9 of the treaty of the 11th of January, 1909, between the United States and Great Britain. (A copy of the letter of reference is inclosed for your informa tion.)

It is desired to expedite the completion of the duty confided to you by utilizing all available surveys and other reliable information, whether derived from public or from private sources. That a proper basis of procedure may be agreed upon in the first instance, and the field work and the preparation of plans and esti mates promptly and efficiently carried on thereafter, you are requested t confer fully and freely with (name of individual to be inserted)[1]; who has bee designated to take charge of corresponding duties on behalf of the (name o country to be inserted), to arrange for the division of the field work and fo cooperation in the preparation of the desired plans and estimates. While it is clear that the field work necessary to complete existing information may prop erly and advantageously be divided, cooperation and unity in the preparation o plans and estimates seem preferable.

[1] On Jan. 30, 1920, the Government of the United States appointed Lieut. Col. W. P Wooten, of the Corps of Engineers, U. S. Army, and on Apr. 14, 1920, the Government o Canada appointed W. A. Bowden, Chief Engineer of the Department of Railways an Canals, Canada. These officers will be referred to hereafter as the engineering board.

It will be noted that the reference to the joint commission contemplates four different general schemes or methods of improvement, as follows:

(*a*) By means of locks and navigation dams in the river.

(*b*) By means of locks and side canals.

(*c*) By a combination of the two preceding methods.

(*d*) By means of locks and power dams.

The plans and estimates should definitely cover these four general schemes or methods of improvement, but other variations of them may be considered, and, if deemed desirable, also presented to the commission.

The channels to be considered are to be of 25 and 30 feet depth at low water, and the plans and estimates should be prepared correspondingly. A choice between them will, under the terms of the reference, be made by the commission.

As detailed plans can not be prepared within the time limit of one year fixed for this work, it is desired that merely outline plans and lump-sum estimates, based upon experience from similar work—such as the enlargement of the Welland Canal and power development at Niagara Falls—should be submitted.

The general schemes should be furnished to the commission, showing, first, the best for navigation alone, and, second, for the most efficient utilization of the waters of the St. Lawrence for navigation and power, together with the approximate costs thereof.

As the handling and disposal of ice is a fundamental difficulty on the St. Lawrence River, the arrangements regarded as being necessary for this purpose should be discussed as well as those recommended for ice disposal during the construction period and thereafter.

Regulation of the levels of Lake Ontario so as to equalize the discharge of the St. Lawrence may be desirable in the interest of navigataion, of ice disposal, and of power development. If the plans include any provisions for such regulation an explanation should be furnished to make clear just what is proposed.

Finally, you are requested to keep the International Joint Commission fully advised of your progress and to maintain close and sympathetic touch with it so as to insure complete coordination.

INTERPRETATION OF REFERENCE.

Reduced to its simplest terms, the reference requires the commission to recommend to the two Governments a plan that will secure from the waters of the upper St. Lawrence their maximum efficiency in navigation and power. At the outset it is clear that this is a problem of exceptional magnitude and intricacy and one involving national and international interests of very great importance. If the proposed improvement is carried out it must necessarily involve very considerable expenditures by the Governments of the United States and Canada, and at a time when the people of these two countries have to bear their share of the gigantic financial burden imposed by the greatest war in history. The commission is therefore conscious of a very heavy responsibility. Its conclusions and recommendations must be based upon a thorough knowledge of all the factors entering into the problem, economic as well as engineering. With that knowledge before it, it must first determine whether or not the project as a whole is practicable; and if so, in what way it can be carried out so as to secure the maximum benefits to the people of the two countries.

As to the engineering side of the question, the commission was not concerned with that until such time as the engineering board should submit its report. It was therefore free to devote all its energy to accumulating data bearing upon the economics of the problem, and too much emphasis can not be put upon the fact that the economic aspects of the St. Lawrence improvement present a problem that is

not only large and important but many-sided. Even a preliminary survey of the question made it clear that no intelligent consideration could be given to the development of the maximum efficiency of the upper St. Lawrence without at the same time taking into account the whole system of the Great Lakes and their outlet to the sea. In fact, the inquiry led even further afield, for it demanded consideration of the interests of the entire territory economically tributary to the Great Lakes. And from the point of view of water power it required a study of conditions throughout the region which, under present-day conditions of electrical transmission, might profitably be served with power developed on the upper St. Lawrence. The problem in its larger aspects, therefore, becomes one involving enormous interests and intimately affecting the welfare of a very large population on both sides of the international boundary between the Atlantic seaboard and the Rocky Mountains.

SCOPE OF INVESTIGATION.

As the first step toward marshaling the evidence, the commission had prepared a series of briefs covering the material already available in printed or other documentary form bearing upon the subject matter of the investigation. With these before it, a preliminary hearing was held at Buffalo on March 1, 1920, at which the views were obtained of representatives of various commercial and other organizations as to the general scope of the investigation and the main aspects of the problem. Thereafter the commission held public hearings at various points on both sides of the international boundary, from Boston, New York, and Montreal in the East to Boise and Calgary in the West, at which everyone interested in the investigation, whether his views were favorable or unfavorable, was given the fullest possible opportunity of submitting facts or opinions bearing upon the subject matter of the reference. These hearings resulted in the accumulation of an immense body of testimony, which has since been carefully digested so as to bring together all the essential elements. The commission has also availed itself of the services of statistical experts, both in Washington and Ottawa, who have analyzed and checked the statistical data submitted at the various hearings, procured additional material, and put the whole into the form of comprehensive statistical studies of the situation.

On July 2, 1921, the engineering board filed with the commission the text of its report on the engineering features of the investigation, together with a number of the drawings accompanying the same. At subsequent dates Appendices A, B and C, containing, respectively, the detailed estimates and two separate reports on the regulation of Lake Ontario, were filed, as well as the balance of the drawings. The complete report was in the hands of the commission on August 24; copies of the report and appendices were made for the use of the commission, but as the set of drawings numbered 64 and each had to be hand-colored, some further time elapsed before reduced sets could be made available. On August 15–18 the commission, with the members of the engineering board, made a careful inspection of the St. Lawrence from Lake Ontario down to Montreal, with particular reference to the points at which works were recommended in the engineers' report.

Up to this time the report and plans had been studied, and that tentatively, only by the members of the commission, but it was decided that opportunity should be given to all interested engineers to examine them, copies being available in the offices of the commission at Ottawa and Washington and in the offices of the United States Corps of Engineers at Detroit. Thirty days from August 20 were allowed for the purpose of studying the report and plans and 10 days additional within which to file with the commission any comments or criticisms or alternative schemes. The material so filed was considered by the commission, in consultation with the engineering board, at the annual meeting in Ottawa on October 5, when it was also ascertained that the Hydro-Electric Power Commission of Ontario, which had been investigating for some years past the power possibilities of the upper St. Lawrence, and the New York & Ontario Power Co., which had given a good deal of thought to the same question, desired to submit alternative plans to the commission and, as they were not yet ready, asked for an extension of time. The commission granted extensions of time to the first week of November, and it also decided to hold a final hearing at Ottawa on November 14, at which all engineers interested in the technical features of the St. Lawrence investigation would have an opportunity of discussing the report of the engineering board, together with the various alternative schemes filed with the commission.

It will be remembered that by the terms of the reference the engineering board was given 12 months within which to file its report with the commission, and the commission was requested to file its report with the two Governments 3 months thereafter. The 12-month period ran from the date of appointment of the engineers, and as these appointments were of different date, the last being April 15, 1920, the period within which surveys, plans, and estimates were to be filed with the commission expired on April 15, 1921. But, as already mentioned, the report of the engineering board was not completely filed with the commission until August 24. The commission wishes it to be distinctly understood that it has no thought of criticizing the engineering board for the delay in filing this report. On the contrary, in the opinion of the commission the period of 12 months was entirely inadequate to the requirements of an engineering problem of such exceptional character and magnitude, and the report and plans of the board as finally submitted were much more complete than the commission had anticipated. Nevertheless the fact remains that by the time the engineering report had been filed and studied by the commission, opportunity afforded all interested parties to examine it and file criticisms or submit alternative schemes, all of which were discussed at the hearing on November 14, the date fixed for the submission of the commission's report to the two Governments, even under the most liberal interpretation, had expired. The commission has, however, used all possible diligence in the preparation of its report in order to file it with the two Governments at the earliest practicable moment.

In the following pages the commission has endeavored to bring together all the material essential to a clear understanding of the problem. In Part II is presented what may be called the background of the picture—that is to say, the physical characteristics

of the St. Lawrence Basin, the artificial improvements carried out by both Governments in the past in these waters, and a short account of the development of commerce on the Great Lakes. In Parts III and IV the commission presents an analysis of the testimony submitted at the various hearings as to the economic practicability of the improvement, with various other economic data brought together by the commission or on its behalf. Part V is devoted to a similar treatment of the water-power problem. Part VI embodies the commission's conclusions and recommendations as to the engineering and economic practicability of the proposed improvement, with the best means of carrying it out. In the appendix the commission submits such relevant material as it believes should be before the two Governments when they consider this report.

PART II.

THE ST. LAWRENCE BASIN.

The object of the present investigation being to secure the completion of the last link in the chain of deep-water navigation extending from the head of the Great Lakes to the Gulf of St. Lawrence, it will be convenient at the outset to give some account of the physical characteristics of this great system of waterways, together with the progressive efforts that have been made by the governments of these two countries to improve navigation, and a very brief history of the development of commerce.

PHYSICAL CHARACTERISTICS.

The St. Lawrence River proper rises in Lake Ontario and discharges its waters into the Gulf of St. Lawrence, but its ultimate source is at the head of the St. Louis River, at the extreme end of Lake Superior, 1,870 miles from the gulf. The basin of the St. Lawrence is a great transverse valley, 309,500 square miles in area, extending from the Gulf of St. Lawrence into the heart of the continent. Much the larger part of the basin lies north of the boundary, as all its great tributaries flow in on that side. It is separated by a low divide from the Hudson Bay Basin, and from the Mississippi Basin by an even lower divide.

The St. Lawrence is remarkable for the number of expansions in its course. Starting with Lake Superior, which empties through St. Marys River, the next great expansion is Lake Huron and Lake Michigan, which both discharge through St. Clair River into Lake St. Clair, thence by Detroit River into Lake Erie and by the Niagara into Lake Ontario. The St. Lawrence proper has in its course three minor expansions—Lake St. Francis, Lake St. Louis, and Lake St. Peter—the first and second above and the third below Montreal. The total fall between Lake Superior and the gulf is 603 feet. The waterway, taken as a whole, is generally deep, the shoalest places being in St. Marys River, Lake St. Clair, Lake St. Louis, and Lake St. Peter.

Taking the lakes in the order mentioned above, Lake Superior is not only the uppermost but the largest, although few rivers of any size contribute to its volume. It is 383 miles long, with an average width of 80 miles, and its area is 31,800 square miles. Lake Huron has an area of 23,200 square miles, and is 223 miles long, with an average breadth of 100 miles. Lake Michigan is 321 miles long, with an average width of 58 miles, and covers an area of 22,450 square miles. Lake St. Clair is 26 miles long, with an average width of 20 miles and an area of 445 square miles. Lake Erie is 236 miles

long, with an average width of 38 miles and an area of 9,940 square miles. Lake Ontario is 190 miles long, with an average width of 40 miles, and covers an area of 7,260 square miles. The mean and maximum depths in the various lakes are as follows: Superior, 475 and 1,012; Huron, 250 and 750; Michigan, 325 and 870; Erie, 70 and 210; and Ontario, 300 and 738.

The St. Lawrence proper is a noble stream flowing from 1 to 3 miles in width from Lake Ontario to the city of Quebec, and with a much greater width from Quebec to the Gulf. The river is navigable for all classes of vessels down to Prescott, where the Galops Rapids begin. Below these are the Rapide Plat and the Long Sault, the latter immediately above Cornwall. Lake St. Francis follows, and between that lake and Lake St. Louis are three series of rapids, the Coteau, Cedars, and Cascades. The last rapids are the Lachine and a minor fall at Montreal known as St. Mary current. No rapids break the course of the river below Montreal. The tide is first felt at Three Rivers. Opposite Quebec the river forms a deep basin, one of the great natural harbors of the world.

For the purposes of this report it will not be necessary to mention more than a few of the more important tributaries that flow into the Great Lakes and the St. Lawrence proper. Nothing but small streams discharge into Lake Superior from the south. On the north side of the lake the Nipigon, Kaministitwia, Pic, and Michipicoten are streams of importance. The Menominee and Fox Rivers of Green Bay and the St. Joseph and Grand Rivers on the east side are the principal feeders of Lake Michigan. Lake Huron, despite its great area, has very few affluents of any size, the principal being French River, discharging Lake Nipissing into Georgian Bay, and the Severn, which drains Lake Simcoe. The Thames, one of the largest rivers of the peninsula of Ontario, drains into Lake St. Clair. The principal southern tributaries of Lake Erie are the Maumee and the Sandusky, and on the north shore the Grand River. Lake Ontario has the Genesee and Oswego Rivers as its largest feeders from the south, and the Trent from the north.

The basin of the St. Lawrence broadens out eastward of Lake Huron, and consequently the great tributaries of the water system flow into the St. Lawrence proper, the principal of these being the Ottawa, a river 685 miles long, rising far to the north. One of its branches, the Mattawa, rises close to the eastern end of Lake Nipissing. The Ottawa joins the St. Lawrence near Montreal, its darker water flowing side by side with the bright blue St. Lawrence clearly distinguishable for a short distance until they intermingle. Other large tributaries on the north bank are the St. Maurice, which joins the main river at Three Rivers, the Batiscan, St. Anne, Jacques Cartier, and the Saguenay, with several others down toward the gulf. On the southern shore the principal tributaries are the Richelieu, which discharges the waters of Lake Champlain and Lake George, the St. Francis, Yamaska, and Chaudiere.

ARTIFICIAL IMPROVEMENTS.

In dealing with the artificial waterways and other improvements in the St. Lawrence Basin, the subject will be dealt with in the following order: (a) St. Lawrence Ship Channel; (b) canals between

Montreal and Lake Ontario; (c) Welland Canal, past, present, and future; (d) canals at Sault Ste. Marie; (e) minor canals in the basin; (f) canals not connecting boundary waters; (g) channel improvements in connecting rivers; (h) harbor improvements; (i) aids to navigation.

(A) ST. LAWRENCE SHIP CHANNEL.

The history of the St. Lawrence Ship Channel goes back to 1825, when the Hon. John Young, of Montreal, and other public-spirited citizens began an agitation for the improvement of this great natural waterway. As an engineering work the St. Lawrence Ship Channel has special interest. When first undertaken it was considered of its kind a work of unusual magnitude, and it is still quoted as one of the great dredging projects of the world. Though not the birthplace of dredges, the ship channel takes a first place among the works where great improvements have been applied to dredges and methods of dredging which have resulted in their present efficiency and development. It is also of special interest to note that, unlike most river works, the St. Lawrence Ship Channel costs nothing for maintenance. From the Great Lakes the pure water passes through the rocky channels of the Thousand Islands and several rapids that lead to Montreal. Thence the river flows with a gentle current, bearing no detritus, and the artificial deepening when once made remains permanent, without either silting up or scouring out of shape.

The St. Lawrence Ship Channel is so vital a link in the chain of water communication between the Great Lakes and the sea that it seems worth while to describe its history in some detail. In the year 1826 the improvement of the ship channel between Montreal and Quebec was taken up as a matter of public importance by the legislative assembly of Lower Canada. The committee appointed to investigate the matter, having procured plans of Lake St. Peter and examined a number of witnesses, reported that the importance of the subject required that further information should be obtained.

In the next year the subject was again discussed and a committee appointed to make further investigation. The need of a thorough survey was felt; and, in view of the fact that the Admiralty survey of the St. Lawrence was then in progress and would soon reach Lake St. Peter, further inquiry was deferred until a report of the Admiralty survey could be obtained. In compliance with the request which had been made by Sir James Kempt, Capt. Bayfield, having made this survey, submitted his observations on the nature of the lake, its channels, etc., in May, 1831. This report, accompanying a message from Lord Aylmer, governor in chief, was transmitted to the House in December, 1831, and referred to a committee of five members to report on the same. No action immediately followed, however, and again, in 1836, the matter was discussed and evidence taken before the standing committee of trade. The Admiralty chart of the lake had not yet been received, and this seems to have delayed further action, for on May 5, 1838, an ordinance was passed granting £500 for the purpose of making a survey of Lake St. Peter.

Nothing official is recorded of what followed this grant until 1841, when Secretary Daly, referring to the petition of the board of trade,

writes to the chairman of the select committee that "His Excellency has commanded me to inform you that the improvement of the navigation of Lake St. Peter will be considered with other public works." An extensive investigation was made by a special committee of the House in August, 1841, into the "extent of the burden imposed on the trade by the obstructions to the navigation which it is sought to remove," and an estimate of the cost of deepening the channel in the lake to 16 feet deep at low water was made by David Thompson. The result of the investigation was the recommendation by the special committee of the House that "measures may be taken to deepen the ship channel in Lake St. Peter."

During this investigation the committee discussed the proposal of a tonnage duty on the shipping coming up to Montreal, but while they believed that a tonnage duty, sufficient to provide for the cost of deepening the channel, would be much less burdensome to the trade than the cost for lighterage then was, yet they deemed that "in order to draw the produce of the West down the St. Lawrence, it is expedient to make the transit charges as light as possible," thus clearly recognizing the national character of the St Lawrence Ship Channel. Action was taken on the recommendation of the report and an appropriation was inserted in the estimates for the prosecution of the work, which was styled, in the report of the board of works for 1841, a subject of very great importance.

The expediency of the work being now decided, a question arose as to the best location for the channel in Lake St. Peter. Charles Atherton, C. E., reported in favor of deepening the natural channel then used in the lake, but his advice was not followed and work was begun in the "straight" or "board of works" channel, in the spring of 1844. But many of those who were the strongest advocates of the proposed improvements objected to this location, maintaining that the desired object could be attained sooner, more effectually, and at a less cost, by deepening the natural channel. This opposition to the straight channel increased during the progress of the work, and caused its temporary suspension in the summer of 1846, and its final suspension in the fall of 1847.

Discussions and investigations continued until 1850, when the Harbor Commissioners of Montreal proposed a plan for the accomplishment of the work, believing that they could execute it successfully by methods more economical and expeditious than had been adopted by the board of works. They proposed "that the Harbor Commissioners of Montreal should be authorized to undertake the work and to borrow money, the interest of which should not exceed 8 per cent, and this interest, as well as a sinking fund of 2 per cent, was to be provided for by a tonnage duty not exceeding 1 shilling per ton register on all vessels drawing 10 feet and upward for each time they passed through the lake, and should the revenue so collected prove insufficient to pay the interest on moneys borrowed, the surplus revenues of the harbor of Montreal were to be applied to make up and deficiency. This plan was adopted by the Government, and an act of Parliament procured in accordance with it" (viz, acts 13 and 14 Vic., Cap. 97, passed August, 1850), authorizing the commissioners to borrow £30,000 for the purpose of proceeding with the work "in such a manner, direction, and place as the commissioners should

deem best." Thus far the work had been carried on with dredging plant belonging to the Government under the direct supervision of Government officers, and the plant was now transferred to the harbor commissioners for continuing the work.

The commissioners forthwith appointed a board of engineers to inquire into and report on the best means of obtaining a channel of 16 feet depth through Lake St. Peter. After inquiring into the state and nature of the two channels these engineers reported in favor of abandoning the straight channel and of applying the work of improvement to the old or natural channel. The harbor commissioners adopted their recommendation and began operations in the old or natural channel in June, 1851. Early and continued success accompanied their efforts, and a rapid increase of shipping attended the available improvements of the channel. By November, 1851, the natural channel in the lake of about 10 feet 6 inches at low water was deepened 2 feet. In August, 1853, a vessel passed through the dredged channel from Montreal to the foot of Lake St. Peter, drawing 4 feet more than the original depth of water. In 1855, 16½ feet depth at low water was attained, and 18 feet depth was accomplished in 1857.

These results were reassuring and demonstrated the feasibility of obtaining a channel of the required depth up to the entrance of the Lachine Canal, the natural junction of the ocean and inland shipping of the country. The harbor commissioners now represented to the Government the national character of the work, urging that the benefits derived from the improvements in the channel were not confined to Montreal, but extended to the whole of the country lying to the westward, and prayed that the revenue of the harbor of Montreal might be relieved of the burden unjustly laid upon it. John Page, C. E., then chief engineer of public works, in his report on the ship channel, dated January 25, 1869, referring to this matter says: "These views having been repeatedly brought before the Government, after a full discussion of the question, it was decided in 1860 that the river improvements should henceforth be considered as public works."

Thus it is clear that in 1860 the deepening of the ship channel between Montreal and Quebec was recognized and acknowledged to be a public work, and so continued to be considered, inasmuch as in 1866, almost the entire debt of the 20-foot channel was assumed and paid by the Government. The further deepening has been carried on by the harbor commissioners, under the authority of the Dominion Government, with funds provided by the sale of Government debentures, the interest on which is paid out of the harbor dues.

The decided success which attended the earlier operations of the harbor commissioners in the ship channel has been even surpassed by their subsequent achievements. Through improvements applied to the dredges their efficiency was greatly increased, both in expediting the work and in lessening its cost. In 1878 a depth of 22 feet in the channel was attained. The cost of dredging in Lake St. Peter was reduced in 1881 to $3\frac{8}{10}$ cents per cubic yard. The work of obtaining a channel of 25 feet depth was accomplished in 1882, and the further deepening to 27½ feet at low water was proceeded with.

The above is taken, partly in a summarized form, from the introduction to the volume of Official Documents and Other Information Relating to the Improvement of the Ship Channel Between Montreal and Quebec, published in 1884. This volume contains full particulars as to the history and development of the ship channel down to that year. Its subsequent history will be found in the annual reports of the Department of Public Works and the Department of Marine and Fisheries.

The ship channel was under the jurisdiction of the Montreal Harbor Commissioners from 1851 to 1888, when it was transferred to the Department of Public Works, Canada. It remained under that department until 1904, when the work was turned over to the Department of Marine and Fisheries of Canada, by whom it is still being carried on. Under the harbor commissioners the channel was gradually deepened, and when they turned it over to the Department of Public Works in 1888 the section from Montreal to Cap a la Roche had been dredged to 27½ feet at ordinary low water, and from Cap a la Roche to Quebec to 27½ feet at half tide. Between 1889 and 1899 the Department of Public Works widened and cleaned up the channel and deepened the section between Cap a la Roche and Cap Charles to 27½ feet at ordinary low water.

In 1899 work was begun on the 30-foot channel, which was also to be widened to a minimum width of 450 feet and straightened. The important project was carried on throughout the period the ship channel remained under the control of the Department of Public Works, and was continued by the Department of Marine and Fisheries. It is not yet quite completed in the lower portions of the river. Meanwhile in 1910 the Department of Marine and Fisheries began work in the upper divisions of the river to increase the depth of the channel to 35 feet. Something over 40 miles have now been completed to 35 feet. The total expenditure on the ship channel up to March 31, 1921, has been $23,867,967.

(B) CANALS BETWEEN MONTREAL AND LAKE ONTARIO.

The first lock canals in Canada were built on the St. Lawrence around the upper and lower of the three rapids between Lake St. Francis and Lake St. Louis. They were built by the Royal Engineers, and finished in 1783. The locks were 120 feet long, 9 feet wide, with 6 feet of water on the sill.

In 1815 money was voted by Lower Canada for the construction of the Lachine Canal, and the work was completed in 1825. This canal was 48 feet wide at the water surface and 4½ feet deep. There were seven locks, each 108 feet long and 20 feet wide, built of masonry.

In 1818 a joint commission from Upper and Lower Canada reported in favor of a canal system for the St. Lawrence, with 4 feet depth of water, that being the then depth of the Erie Canal.

The year after the Lachine Canal was completed the Royal Engineers recommended longer and wider locks for the St. Lawrence, with 8 feet of water, and in 1832 a decision was come to that the depth of water should be 9 feet.

The Cornwall Canal was commenced in 1834, but the rebellion of 1837–38 interfered with its completion, and it was not completed until 1843. Its locks were 200 feet long, 55 feet wide, and it had 9 feet of water on the sill.

The Beauharnois Canal was enlarged about the same time to similar dimensions, and was opened in 1848.

The canals at Farrans Point and Rapide Plat and the Galops, now known as the Williamsburg Canals, were completed in 1847, upon the same scale as the Beauharnois Canal, thus providing a 9-foot waterway from Lake Ontario to Montreal.

In 1871 a commission appointed by the Dominion Government advised a uniform scale of navigation for the St. Lawrence canals, with locks 270 feet by 45 feet, and 12 feet of water on the sill. However, in 1875 the Dominion Parliament ordered that the enlarged canals should be deepened so as to pass vessels drawing 14 feet of water, and this was done without regard to the other dimensions of the locks. The canals were gradually enlarged to these dimensions, and vessels 260 feet long, 44-foot beam, can pass between Montreal and Lake Superior, loaded down to about 14 feet. The locks were found to be too short before completion.

From Montreal to Prescott is 119.10 miles, 40 per cent of which is through canals, but as the level of Lake Ontario is reached above Galops Rapids, 111.35 miles from Montreal, a little more than 40 per cent of the distance to Lake Ontario level is through canals. This distance of 119 miles is covered by the Richelieu and Ontario boats in 8 hours coming down and in 19 hours going west.

To the foregoing information, for some of which the commission is indebted to a paper by Henry Holgate on "The Upper St. Lawrence River," may be added the following detailed statement of the St. Lawrence River canals taken from a blue book issued by the Department of Railways and Canals entitled "St. Lawrence River Route and Canals, 1918":

Lachine Canal.

Legth of canal	8½ statute miles.
Number of locks	5.
Dimensions of locks	270 feet by 45 feet.
Total rise of lockage	45 feet.
Depth of water on sills, at 2 locks	18 feet.
Depth of water on sills, at 3 locks	14 feet.
Average width of new canal	130 feet.

The old lift locks, 200 feet by 45 feet, are still available, with 9 feet on miter sills. The two lower north locks, however, have been lengthened to 270 feet, and have 16½ feet of water on the sills.

The canal consists of one channel, with two distinct systems of locks, the old and the enlarged. There are two lock entrances at each end.

The canal extends from the city of Montreal to the town of Lachine, overcoming the St. Louis Rapids, the first of the series of rapids which bar the ascent of the river St. Lawrence. They are 986 miles distant from the Strait of Belle Isle.

Soulanges Canal.

Length of canal	14 statute miles.
Number of locks:	
Lift	4.
Guard	1.
Dimensions of locks	280 feet by 45 feet.
Total rise of lockage	84 feet.
Depth of water on sills	15 feet.
Breadth of canal at bottom	100 feet.
Breadth of canal at water surface	164 feet.

The canal extends from Cascades Point to Coteau Landing, overcoming the Cascades Rapids, Cedar Rapids, and Coteau Rapids.

From the head of the Lachine Canal to the foot of the Soulanges Canal the distance is 16 miles.

Cornwall Canal.

Length of canal	11 statute miles.
Number of locks	6.
Guard locks	1.
Dimensions of locks	270 feet by 45 feet.
Total rise of lockage	48 feet.
Depth of water on sills	14 feet.
Breadth of canal at bottom	90 feet.
Breadth of canal at water surface	154 feet.

From the head of the Soulanges Canal to the foot of the Cornwall Canal there is a stretch through Lake St. Francis, 31 miles, which is navigable for vessels drawing 14 feet.

The Cornwall Canal extends past the Long Sault Rapids from the town of Cornwall to Dickinsons Landing.

WILLIAMSBURG CANALS.

The Farrans Point, Rapide Plat, and Galops canals are collectively known as the Williamsburg canals.

Farrans Point Canal.

Length of canal	1½ miles.
Number of locks	1.
New lock	800 feet by 50 feet.
Old lock	200 feet by 45 feet.
Total rise of lockage	3½ feet.
Depth of water on sills of new lock	14 feet.
Depth of water on sills of old lock	9 feet.
Breadth of canal at bottom	90 feet.
Breadth of canal at water surface	154 feet.

From the head of the Cornwall Canal to the foot of Farrans Point Canal the distance on the River St. Lawrence is 5 miles. The latter canal enables vessels ascending the river to avoid Farrans Point Rapids, passing the full tow at one lockage. Descending vessels run the rapids with ease and safety.

Rapide Plat Canal.

Length of canal	3⅔ miles.
Number of locks	2
Dimensions of locks	270 by 45 feet.
Total rise or lockage	11½ feet.
Depth of water on sills	14 feet.
Breadth of canal at bottom	80 feet.
Breadth of canal at water surface	152 feet.

The old lift lock, 300 feet by 45 feet, is also available with 9 feet of water on miter sills.

From the head of Farrans Point Canal to the foot of Rapide Plat Canal there is a navigable stretch of 9½ miles. The canal was formed to enable vessels ascending the river to pass the rapids at that place. Descending vessels run the rapids safely.

Galops Canal.

Length of canal	7½ miles.
Number of locks	3
Dimensions of locks:	
Lift lock at foot of canal	800 by 50 feet.
Guard lock at head of canal	270 by 45 feet.
Lift lock to pass vessels around Galops Rapids only	303 by 45 feet.
Total rise or lockage	15½ feet.
Depth of water on sills	14 feet.
Breadth of canal at bottom	80 feet.
Breadth of canal at surface of water	144 feet.

From the head of Rapide Plat Canal to Iroquois, at the foot of the Galops Canal, the St. Lawrence is navigable 4½ miles. The canal enables vessels to overcome the rapids at Pointe aux Iroquois, Point Cardinal, and the Galops.

The total expenditure on the St. Lawrence River canals—that is to say, the canals between Lake Ontario and Montreal—up to March 31, 1921, was $54,626,138.77.

(C) WELLAND CANAL—PAST, PRESENT, AND FUTURE.

The building of the first Welland Canal was mainly due to the enthusiasm and untiring efforts of William Hamilton Merritt. The matter was brought before the Legislature of Upper Canada early in the nineteenth century, but as the legislature showed timidity, Merritt in 1824 organized the Welland Canal Co. This was shortly after the opening of the Erie Canal. The company was incorporated with a capital of £40,000. The original intention was to build the canal for boats of 4-foot draft, and a capacity of not more than 40 tons, and to tunnel under the high ridges, but this was abandoned as impracticable. The Government of Upper Canada, although it had declined to undertake the building of the canal as a Government measure, subscribed liberally to the stock of the Welland Canal Co., as did also the British Government. The work was rapidly pushed forward and toward the end of 1828 was almost completed, when a mile or more of the high bank in what was known as the Deep Cup slid in and destroyed a considerable portion of the work. The British Government came forward immediately with a loan of £50,000 and the canal was finally completed and opened in 1829.

This first Welland Canal had 40 wooden locks, 110 feet long, 22 feet wide, and with 8 feet of water over the sills. On the union of Upper and Lower Canada in 1840, the Government took over the canal and replaced the 40 wooden locks with 27 stone locks, ranging in length from 150 to 230 feet, with a width of from 26½ to 45 feet, and the depth of water on the sills of 10¼ feet.

In 1871, the original canal having been found inadequate to meet the traffic, it was decided to build a new canal from Allanburg to

Port Dalhousie, a distance of 11⅞ miles. Twenty-five masonry lift locks with uniform dimensions of 370 feet by 45 feet were provided with a depth of 12 feet on the sills, but before the work had progressed very far it was decided to make all permanent structures adaptable to a 14-foot depth. It was not, however, until 1887 that the canal was finally completed to that depth.

As the country had outgrown the original canal, so in course of time it also outgrew the capacity of the second canal, and a few years before the European war the Government decided to build a third canal of sufficient capacity to accommodate the largest vessels likely to be built for service on the Great Lakes. The new project, therefore, developed into a ship canal, with only seven locks, each being 800 feet long by 80 feet wide, with a depth at extreme low water of 30 feet, the canal to be 25 feet deep, with provision for a 35-foot channel when conditions should make it desirable. The new canal, which is now well under construction, runs from Port Colborne, on Lake Erie, to Port Weller, on Lake Ontario. The difference in level between the two lakes is 326 feet, and each of the seven locks will have a lift of 46½ feet.

Facilities at both ends of the canal will be much better than at present. A new breakwater will be constructed at Port Colborne, providing a safe anchorage in case of storm. The piers at Port Weller will be run out a mile and a half from shore, to insure the required 30-foot depth. Between these piers a 500-foot channel will be dredged, and an embankment built on either side of it. At the outer ends of these embankments, piers 700 feet long will be constructed, leaving a 400-foot entrance for vessels.

One of the most remarkable engineering undertakings in connection with the project has been the method employed in building the entrance piers. Huge concrete cribs were built at Port Dalhousie, then floated to Port Weller and sunk. More than 50 of these cribs have to be built altogether, of which some 15 are already in position. The general dimensions of these cribs are 110 feet long, 38 feet wide, and 34 feet in height. When this work is completed Port Weller will be a very commodious harbor, and may also become an important industrial center.

The total expenditures for construction, enlargement, and maintenance of the first and second canals amounts to $41,505,969.78 up to 1921. The estimated cost of the new ship canal was $50,000,000, but $25,340,135.82 has already been spent upon it, and the completed work will probably cost considerably more than the original estimate.

(D) CANALS AT SAULT STE. MARIE.

The first canal was built on the Canadian side of the river in 1797-98 by the North West Co. The lock was 38 feet long, 8 feet 9 inches wide, with a lift of 9 feet. A towpath was made along the shore for oxen to track the bateaux and canoes through the upper part of the rapids. The lock, excepting its timber floor and miter sills, was destroyed in 1814 by United States troops from Mackinac Island under command of Maj. Holmes. About a hundred years later the lock was restored, and is now preserved as a relic of the past. An account of the circumstances under which the canal and lock were built is found in Canadian Archives Report for 1886.

The first ship canal, known as the State Canal, was built on the American side of the river in 1853 to 1855, some 750,000 acres of land in Michigan having been granted by the United States Congress for the construction thereof. The canal was $1\frac{1}{2}$ miles long, 64 feet wide at the bottom, and 100 feet wide at the water surface. There were two tandem locks of masonry, each 350 feet long by 70 feet wide, with a lift of about 9 feet. The depth in the canal was about 13 feet and in the locks about $11\frac{1}{2}$ feet, at the stage of water then prevailing. The locks were destroyed in 1888 by excavations for the present Poe Lock.

The Weitzel Lock, 515 feet long, 80 feet wide in chamber, narrowing to 60 feet at the gates, with 17 feet depth of water on the miter sills, was built by the United States in the years 1870 and 1881. During the same period the canal was correspondingly deepened and was widened to 160 feet, and the stone slope walls were replaced with timber piers having a vertical face.

The Canadian canal is $1\frac{1}{10}$ miles long, or 7,472 feet, between the extreme ends of the entrance piers. The canal is 150 feet wide at the surface and 23 feet deep. The single lock is 900 feet long and 60 feet wide, having 22 feet of water on the miter sills. It was constructed through St. Marys Island on the north side of the river between the years 1886 and 1895.

The Poe Lock, 800 feet long, 100 feet wide, and having 22 feet of water on the sills, was built by the United States in the years 1887 to 1896.

The depths on the miter sills of the locks above mentioned are referred to the mean stage of water prevailing at the time they were projected. At extreme low-water stages of the lower pool the draft that can be carried through the locks is about 4 feet less than the project depths given above.

The Third Lock, 1,350 feet long and 80 feet wide, and having $24\frac{1}{2}$ feet of water upon its miter sills at existing stages, was built by the United States in the years 1908 to 1914, and opened to traffic October 21 of the latter year. The Fourth Lock, of same dimensions as the Third, was completed in 1919.

Since 1892 the canal leading to the Weitzel and Poe Locks has been deepened in its upper reach to 24 feet. Since 1908 the United States has built another canal leading to the Third Lock and Fourth Lock, the depth in this canal above and below the locks being 24.5 feet. The length between the upper and lower entrances is about $1\frac{3}{5}$ miles.

The above depths of the present canals are referred to the following low-water planes; 601.6 Lake Superior and 580.6 foot of locks above mean tide at New York, levels of 1903.

The American Canal also practically includes those parts of the channels through St. Marys River which have been improved through shoals of sand, clay, bowlders, sandstone, and limestone rock. The United States Government made the first appropriation for improving the river channels in 1856. The Lake George route was improved for 12 feet draft, 1857 to 1860 and 1866 to 1869. The depth was increased to 16 feet, 1879 to 1883. The Hay Lake route was improved for a depth of 20 feet at mean stage of water, years 1862 to 1894. Betterment of the channels has been continued since that time, so that the dredged areas now total 45 miles in length with

least width of 300 feet, increasing at angles and at other critical places up to 1,000 feet. In 1883 excavation of the Middle Neebish Channel was begun and it was opened to commerce in 1894, being subsequently enlarged between 1902 and 1912. The deepening of the West Neebish Channel was begun in 1903 and it was opened in 1908. Down-bound traffic uses the West Neebish Channel and up-bound traffic the Middle Neebish route. Work is now under way to dredge the Canadian channels in the river to 21.5 feet below low-water level, the existing minimum depth being 18.75 feet below low-water level.

The cost of the several improvements, stated in round numbers, is as follows:

Locks and canal of 1855	$1,000,000
Weitzel Lock	1,000,000
Poe Lock	3,000,000
Third Lock and new canal	5,000,000
Fourth Lock	2,500,000
Widening and deepening canal	4,400,000
Improving channel through river	9,400,000
Canadian Lock, canal, and approaches	5,000,000

Hydraulic power is used for operating the Weitzel and Poe Locks. Electricity generated by water power is used for operating the Third and Fourth Locks on the American side and the Canadian Lock.

The American locks are filled or emptied in about 9 minutes and the gates opened in 1½ minutes. An up-lockage of a single boat has been made through the Poe Lock in 11 minutes and through the Third Lock in 14 minutes.

The Canadian Lock can be operated in about 10 minutes. The average time of lockage through the Canadian Lock last season was 17 minutes and 2 seconds.

From 1855 to 1881 the American Canal was controlled by the State of Michigan and tolls were charged to cover operating and repair expenses, the rate at first being 6½ cents per registered ton, which was gradually reduced to 2½ cents. Similarly the minimum charge for lockage of a boat was reduced from $5 to $3. Since control was transferred to the United States in 1881, the American Canal has been free for public use by all nations. Likewise the Canadian Canal has not collected tolls for either foreign or domestic commerce.

(E) MINOR CANALS IN THE BASIN.

There are two Canadian canals that may be considered as coming within this subdivision, the Trent Canal and the Murray Canal.

Trent Canal.—The name Trent Canal is applied to a series of water stretches forming a connected system of navigation, but until recent years efficient only for local use. By various works this local use has been extended, and by others, now practically completed, it has become a through route between Lake Ontario and Lake Huron. The series is composed of a chain of lakes and rivers extending from Trenton at the mouth of the River Trent on the Bay of Quinte, Lake Ontario, to Honey Harbor, about 10 miles north of Midland, on Georgian Bay, Lake Huron.

Many years ago the utilizing of these waters for the purpose of through water communication between Lake Huron and Lake Ontario was projected. There will be 8 feet 4 inches of water on the sills throughout when the canal is completed. Another passage between Gloucester Pool and Georgian Bay is provided by a small lock at Port Severn with 6 feet of water on the sill. A branch of the main route extending from Sturgeon Lake south affords communication with the town of Lindsay, and through Lake Scugog to Port Perry, a distance of approximately 174 miles from Trenton. There are at present 43 locks in use, 19 of which have 8 feet 4 inches of water on the sills, and the remainder 6 feet. Further details will be found in the pamphlet issued by the Department of Railways and Canals of Canada, entitled "St. Lawrence River Route and Canals, 1918." The total expenditure has been $21,036,842.87.

Murray Canal.—The Murray Canal extends through the Isthmus of Murray giving connection westward between the headwaters of the Bay of Quinte and Lake Ontario, and thus enabling vessels to avoid the open-lake navigation. The length of the canal between the eastern and western piers is 5⅛ miles, the breadth at water surface, low water, Lake Ontario, 124 feet, and the depth below low water, Lake Ontario, 11 feet. Total expenditure, $1,624,667.71.

Beauharnois.—The Beauharnois Canal, which some years ago was replaced by the Soulanges Canal, already described as one of the St. Lawrence River series, has been abandoned for navigation purposes and is at present utilized in part in connection with power development. It connects Lake St. Francis and Lake St. Louis and lies on the south side of the river; the Soulanges, like all the other St. Lawrence canals, being on the north bank.

Projected canals on the Canadian side.—At various times schemes have been worked out for other waterways connecting boundary waters on the Canadian side, but these have never yet got beyond the status of projects.

Huron and Ontario Ship Canal.—In 1871 a series of reports relating to this project, by F. C. Capreol, were published in the form of a pamphlet by order of the council of the corporation of the city of Toronto. This company was chartered by acts of the Canadian Parliament (19, 20 Vic., Cap. 118; 29 Vic., Cap. 7), with an authorized capital of $40,000,000. In these documents the canal proper is stated to be 40 miles, commencing near the mouth of the Humber River on Lake Ontario and following the valley of that river through the village of Berwick, from which place it would follow the eastern branch of that river to the township of King; thence the canal would be cut to the Holland River, which it was proposed to deepen and straighten, to Lake Simcoe. That lake would be utilized as far as Barrie and another canal cut from that point to the Nottawasage River, which would be followed for 15 miles and deepened and straightened as far as Jacks Lake, from which point another canal would be made to the mouth of the Nottawasage to avoid a large detour. The proposed waterway therefore would connect Lake Ontario at or near Toronto with Nottawasage Bay on Georgian Bay. As already mentioned, the canals proper were estimated at 40 miles, and the whole distance from lake to lake, 97 miles. The contemplated works included 42 locks, 27 waste weirs, 4 railway bridges, and 24 other bridges, in addition to terminal harbors, crib protectors, etc.

Lake St. Clair & Lake Erie Ship Canal.—Another Canadian project, somewhat similar to the foregoing, was brought forward about the end of the last century by D. Farrand Henry. It was designed to shorten the distance on the through-lake route and avoid the difficulties in navigating the Detroit River and the west end of Lake Erie. The ship canal was to run from a point on Lake Erie some miles east of Point Pelee to a point on Lake St. Clair near the mouth of the Thames River. It was to be a little over 13 miles in length, with a depth of 21 feet, and a water surface of 156 feet, sloping to 72 feet at the bottom. The estimated cost was about $5,500,000.

Canals on the United States side.—Canals on the United States side which may be included here are the St. Clair Flats Canal, Sturgeon Bay & Lake Michigan Ship Canal, Keeweenaw Waterway, and Black Rock Ship Canal.

St. Clair Flats Canal.—The St. Clair River flows into Lake St. Clair through seven mouths, forming the delta known as the St. Clair Flats. These passes were obstructed by bars in the lake over which there was a least depth of water of from 2 to 6 feet. The existing canal is located in what is known as the south channel. The original project for the construction by the United States Government of a channel through the St. Clair Flats was authorized by the act of March 2, 1867. Subsequent modifications and additions were authorized by the act of March 3, 1873. Nearly $600,000 was expended on these projects up to 1866. In the year named provision was made for a ship canal consisting of two dredged cuts, each 300 feet wide and 20 feet deep, extending from deep water in the St. Clair River a distance of 17,460 feet into Lake St. Clair, these cuts to be separated for a portion of this distance, about 7,221 feet, by a sand dyke, 100 feet wide, revetted on each side by sheet piling, the east side of the east cut to be protected by a dyke of the same length, but only 50 feet in width; it also provided for a channel, 800 feet wide and 20 feet deep, through the shoal at the entrance to the Detroit River, known as Grosse Point Channel. The total expenditure up to and including 1920 was $2,900,000.

The Sturgeon Bay & Lake Michigan Ship Canal.—The Sturgeon Bay & Lake Michigan Ship Canal consists of a revetted canal connecting Lake Michigan and Sturgeon Bay, a basin having an area of about 12 acres inclosed by breakwaters at the Lake Michigan end of the canal, and a dredged channel connecting the westerly end of the canal with deep water in Sturgeon Bay. The canal is one the west shore of Lake Michigan, about 47 miles northeasterly from Green Bay City and about 128 miles northerly from Milwaukee. In its natural condition Lake Michigan was separated from Sturgeon Bay by a neck of land about 1⅞ miles wide, having a maximum elevation above the lake level of about 28 feet. The canal and channel in Sturgeon Bay were originally constructed by a private corporation. The canal then had a width of 100 feet at water line and a depth of about 12 feet with the same depth in the channel. The United States took over the canal in 1893, paying the sum of $323,419.41. Up to 1903, $30,410.21 had been spent for maintenance, making a total of $353,829.62. In 1903 the project was enlarged by providing for an outer harbor, or stilling basin, protected by two converging breakwaters, each 1,344 feet in length, extending from the shore on either

side of the easterly or Lake Michigan end of the canal; for a channel extending from deep water in the lake to the canal entrance at the shore line, a total length of 1,300 feet, varying in width from 600 feet at the outer end in the lake to 160 feet at the canal entrance; for a revetted canal, 7,200 feet in length, varying in width from 160 to 250 feet; and for a channel through Sturgeon Bay from the westerly end of the canal to deep water in the bay, a distance of 4 miles, having a width of 200 feet; all channels to be 19 feet deep at low-water datum. A new project was started in 1903 and completed in 1919. The total expenditure on this waterway has been $653,000.

Keweenaw Waterway.—Keweenaw Waterway is a navigable channel 25 miles long, partly natural and partly artificial, across Keweenaw Point, Mich., with its upper or westerly entrance 166.5 miles east of Duluth, Minn., and its lower or easterly entrance 205.5 miles west of Sault Ste. Marie, Mich. It consists of a continuous channel across Keweenaw Point, with minimum width of 120 feet. The entrances are protected by breakwaters, and harbors of refuge with mooring piers are conveniently located for both entrances.

At the time of the purchase of this waterway by the United States on August 3, 1891, there was a very poor 13-foot navigation; the channel was narrow and crooked, with many sharp bends; it was poorly marked and lighted; the entrance piers were in very bad condition; the revetments were decayed or entirely gone; and there was a tonnage tax on the commerce through the canals. The width of channels in use was 70 feet, and the usable low-water depth was 12.5 feet.

The existing project provides for a navigable channel across Keweenaw Point approximately 25 miles long, 20 feet deep, with least bottom width of 120 feet, with necessary pile and timber revetments; a stone-filled timber pier at the lower entrance extending to 20-foot depth of water, 3,714 feet long; converging stone-filled timber piers at upper entrance, with westerly pier 2,745 feet long and easterly pier 2,485 feet; with an upper-entrance anchorage basin 3,600 feet long by 600 feet wide, with 5,924 feet of pile-timber mooring piers; and with a lower anchorage basin one-half mile long and 800 feet wide, with a pile timber mooring pier 2,000 feet long. The project is practically completed; the expenditure to the end of the season of 1920 was nearly $2,000,000.

Black Rock Channel.—The Black Rock Channel is a waterway on the United States side of the Niagara River providing a safe passage for large vessels around the rapids and shoals in the head of the river. This project is a consolidation and improvement on earlier undertakings in the same channel. The present project provides a channel 21 feet deep and 13½ miles long from Buffalo Harbor north or main entrance channel to a point in the Niagara River opposite Sixth Avenue, North Tonawanda, with general widths of from 200 to 500 feet in the various sections. These consist of the Lake Erie entrance, extending 2,300 feet to Erie Basin north entrance and thence 2,190 feet to the foot of Maryland Street, Buffalo; the Black Rock Canal, extending 3¼ miles to Black Rock Lock, 650 feet long, near the foot of Squaw Island; and the Niagara River Channel for a distance of 9.2 miles to the foot of Tonawanda Island, with a minimum width of 400 feet and terminated with a turning

basin about 1,230 feet long and 1,050 feet wide. It also includes a channel 16 feet deep, 6,800 feet long, and generally 400 feet wide in Tonawanda inner harbor, and 1,400 feet long and generally 180 feet wide in Tonawanda Creek. The United States has spent upon this waterway for construction and maintenance about $4,000,000.

New York State canal system.—The New York State canal system may be noted here because it actually provides a somewhat roundabout connection between Lake Erie and Lake Ontario by way of the Erie Canal and the Oswego Branch, and a much more roundabout route, partly American and partly Canadian, between Lake Erie and Lake Ontario, respectively, and the St. Lawrence River by way of the canals above mentioned and the Champlain Canal from the Hudson River to Lake Champlain, thence by way of the Chambly Canal to the Richelieu River, then through the St. Ours Lock to the lower Richelieu and the St. Lawrence. As the primary object of this canal system is, however, to connect boundary waters with the Hudson River, it is described in more detail under subsection (f).

In addition to the artificial waterways described above, there have been various projects for similar canals at different points on the United States side of the boundary which have never yet got beyond the paper stage. Of these the following will be briefly described: Niagara Ship Canal, Erie & Ontario Sanitary Canal, and Lake Erie & Lake Michigan Ship Canal.

Niagara Ship Canal project.—The project for a canal on American territory between Lake Erie and Lake Ontario has been suggested at various times since the beginning of the nineteenth century. A fairly complete account of the various projects and proposed routes is given in the Report of the Board of Engineers on Deep Waterways between the Great Lakes and the Atlantic Tidewaters, pages 50–60. Of the more recent projects, five surveys and ten different estimates have been made for a canal, in seven of which two different routes have been considered, one from Niagara River above the falls to Lewiston, and thence by the Niagara River to Lake Ontario, and the other from Tonawanda to Lake Ontario to Olcott. All these surveys and estimates contemplated the use of Niagara River from Lake Erie to the entrance of the canal as a part of the route, but as the natural low-water depth at the head of the river is only 17 feet, mean stage, any greater depth of water would necessitate the deepening of the outlet of the lake or a canal around the rapids. Since to deepen the outlet would lower the general level of Lake Erie, a canal around the rapids is the only method by which a deep waterway can be constructed without reducing the depths of lake, harbors, and channels.

The estimate of $23,617,000 made in 1889 for a waterway 100 feet wide and 20.5 feet deep from Tonawanda to Olcott did not include anything for the improvement of the head of the river and therefore does not constitute a complete project for a deep waterway between Lakes Erie and Ontario. All comparative surveys indicate that the route via Lewiston and Niagara River could be constructed at less cost than any of the lines direct to Lake Ontario, but for various reasons the route from Tonawanda to Lake Ontario at Olcott has generally been preferred.

The board of engineers on deep waterways carried out a reconnaissance of the section of country covered by the two routes, which, commencing at deep water in Lake Erie off the entrance to Buffalo

Harbor, run through Black Rock Harbor to near the head of Squaw Island, then lock down to the level of the river below the rapids, and follow the general course of the river to Tonawanda and Cayuga Island, at which points, respectively, the two waterways leave the river.

These two routes are known as the La Salle-Lewiston route and the Tonawanda-Olcott route. The former, following the route described above to Cayuga Island, leaves the river and is carried down to the head of the escarpment above Lewiston; from there it follows the bluff down to the Niagara about a half mile below Lewiston, with 6 double locks of 40 feet lift each and two double locks of 39.4 feet lift each. The fall of the river from the foot of the lowest lock to Lake Ontario, 6 miles, is about 0.2 foot, making the total lockage and slope, from Lake Erie to Lake Ontario, 330 feet. For a distance of 6 miles the prism of the waterway is entirely in rock. Estimates for a 30-foot channel were, in 1900, with Lake Erie regulated, $73,534,350, and with standard low water, $75,084,-453; for a 21-foot channel, Lake Erie regulated, $42,393,203, and with standard low water, $43,214,344. The Tonawanda-Olcott route leaves the Niagara River at the head of Tonawanda Island and is carried down a distance of 13.2 miles to the head of the escarpment west of Lockport, where the ridge to be cut through has an elevation of 636 feet above tidewater, or 71 feet above the water surface in the canal. From the top of the escarpment the line descends to Lake Ontario, 11.2 miles, with two single and three double locks of 40-feet lift each, one single lock with 30.5 feet lift, and three double locks with 30 feet lift each. At a distance about 1 mile above Lake Ontario the line enters the gorge at Eighteenmile Creek and follows it to the lake where, at Olcott, it was proposed to create a harbor by widening Eighteenmile Creek to the width of 400 feet from the last lock to the lake and protecting the entrance by breakwaters. Estimates on this route, for a 30-foot channel, were, with Lake Erie regulated, $75,572,250, and with standard low water, $77,221,353; for a 21-foot channel, with Lake Erie regulated, $48,453,753, and with standard low water, $49,274,894. This project is again reported on in considerable detail by Col. J. G. Warren in his report on diversion of water from the Great Lakes and Niagara River, his estimates running from $120,000,000 for a 25-foot channel to $155,000,000 for a 30-foot channel.

Erie and Ontario Sanitary Canal.—This project, which has repeatedly been brought before the commission at its hearings in connection with the pollution of boundary waters investigation, contemplates the building of a canal from the mouth of Smokes Creek in the city of Lackawanna and passing around the city of Buffalo through a tunnel 6 miles long to Lockport, thence over the escarpment into Eighteenmile Creek, emptying into Lake Ontario. The company asked permission to divert 8,000 second-feet of water from Lake Erie and Niagara River for sanitation, navigation, and power. The project was brought before the commission primarily as a remedy for the pollution of the Niagara River. The commission's consulting sanitary engineer in his report upon remedial measures says:

> The primary function of this canal project is the development of water power, but incidental to such development there are certain possibilities of improved shipping facilities and of the utilization of the canal waters for purposes of sewage dsposal.

In regard to the latter purpose, he was of the opinion that even with the present population the concentration of pollution along the shores of Lake Ontario outside the main current of the Niagara River would become a much more serious menace than the existing conditions and would more than offset any improvement in the condition of the Niagara River; and he pointed out that with the increase of population this condition would be aggravated. The testimony and reports on this project in the publications of the commission will be found in the 1914 hearings, pages 286 et seq., the report of the committee on pollution, 1913, pages 20 et seq., and the report of the consulting sanitary engineer, 1916, pages 16–18 and 77–78.

It may be noted that the following bill was introduced in the House of Representatives on June 20, 1919:

A bill to provide for the construction of a ship canal from Lake Erie to Lake Ontario for the improvement of navigation, to prevent the pollution of international waters in the Niagara River, and the development of water power.

In Col. J. G. Warren's report on investigation of water diversion from Great Lakes and Niagara River, 1921, the conclusion is reached that the above scheme considered as a sanitary project has little to recommend it; as a navigation project it is found to be subject to fatal objections. Its advantages as a power proposition are considered problematical.

Lake Erie and Lake Michigan Ship Canal.—In 1908 the Committee on Railways and Canals of the House of Representatives reported on a resolution to authorize a survey for a ship canal from Lake Erie to Lake Michigan by way of Fort Wayne, and recommended that the resolution be adopted with the amendment that the proposed surveys include other proposed routes for a ship canal between the two lakes. The canal was to run from the most available westerly point of Lake Erie to a point at or near Benton Harbor on Lake Michigan, at an estimated cost of $100,000,000. (See H. Rept. No. 1760, 60th Cong., 1st sess.)

(F) CANALS NOT CONNECTING BOUNDARY WATERS.

Canals on Canadian side.—Of the canals on the Canadian side, coming under this subdivision, the St. Ours Lock and Dam and the Chambly Canal connect the St. Lawrence with Lake Champlain and the Hudson; the Rideau Canal connects Lake Ontario with the Ottawa River; and the St. Annes Lock, Carillon Canal, and Greenville Canal, in conjunction with the Lachine Canal, furnish water transportation between Montreal and Ottawa. The projected Georgian Bay Canal would provide a deep waterway between Montreal and Georgian Bay. Two other projects mentioned below were designed to connect the Ottawa River with the St. Lawrence.

Richelieu River Canals.—The Richelieu River to Lake Champlain route, commencing at Sorel, at the confluence of the rivers St. Lawrence and Richelieu, 46 miles below Montreal, extends along the River Richelieu, through the St. Ours Lock to the basin at Chambly; thence by the Chambly Canal to St. Johns, and up the River Richelieu to Lake Champlain. The distance from Sorel to the boundary line is 81 miles. Minimum depth of water is 6 feet 5 inches. At Whitehall, at the southern end of Lake Champlain, connection is obtained

by means of the Champlain Canal with the Hudson River, by which the city of New York is directly reached.

St. Ours Lock and Dam.—The St. Ours Lock and Dam is one-eighth of a mile in length, with one lock 200 feet long by 45 feet wide, and 7 feet of water on the sills. The dam in the western channel is 690 feet. St. Ours is on the Richelieu River, 14 miles from Sorel. At this point the river is divided by a small island into two channels, the St. Ours Lock being in the eastern channel. There is a navigable depth in the Richelieu of 7 feet between St. Ours Lock and Chambly Basin, a distance of 32 miles.

Chambly Canal.—The Chambly Canal, which overcomes the rapids between Chambly and St. Johns, on the Richelieu River, has a length of 12 miles, with 9 locks, varying in length from 118 to 125 feet, and in width from 22½ to 24 feet. The depth of water on the sills is 6½, and the total rise or lockage, 74 feet. The canal is 60 feet wide at the water surface.

In this connection the following table showing the distance between Sorel and New York will be of interest:

	Miles.
Sorel to St. Ours Lock	14
St. Ours to Chambly Canal	32
Chambly Canal	12
Chambly Canal to boundary line	23
Boundary line to Champlain Canal	111
Champlain Canal to junction with Erie Canal	66
Erie Canal from Junction to Albany	7
Albany to New York City	146
Total distance, Sorel to New York	411

Rideau Canal.—The Rideau system connects the River Ottawa at the city of Ottawa with the eastern end of Lake Ontario at Kingston, a distance of 126¾ miles. There are altogether 47 locks, 33 ascending from Ottawa to the height of land and 14 descending from the height of land to Kingston. The total lockage is 457½ feet. The dimensions of the locks are 134 feet, and the depth of water on the sills, 5 feet, with the same navigation depth through the several reaches. The minimum breadth of the canal at the surface of the water is 80 feet. A branch of the Rideau Canal runs from Beveridges Bay on Lake Rideau to the town of Perth, a distance of 7 miles.

Ottawa River Canals—Ste. Annes Lock.—Of the three works on the Ottawa River, the first, Ste. Annes Lock, is 15 miles above the Lachine Canal. The lock and piers are one-eighth of a mile, the dimensions of the lock being 200 feet by 45, and the depth on the sill 9 feet. This work surmounts the Ste. Annes Rapids between Ile Perrot and the head of the island of Montreal, at the outlet of that portion of the Ottawa River which forms the lake of Two Mountains.

Carillon Canal.—The Carillon Canal, 27 miles above Ste. Annes Lock, overcomes the Carillon Rapids. The canal is three-quarters of a mile in length. There are two locks, each 200 feet long by 45 feet wide, and with 9 feet of water on the sills. Width of canal at water surface, 110 feet.

Grenville Canal.—The Grenville Canal, by which the Long Sault Rapids (Ottawa River) are avoided, is about 56 miles below the city

of Ottawa. The canal is 5¾ miles long, 50 to 80 feet wide, water surface. There are five locks, each 200 feet long by 45 wide, with 9 feet of water on the sills.

Georgian Bay Ship Canal project.—The project of a ship canal between the St. Lawrence and Georgian Bay by way of the Ottawa River, Lake Nipissing, and French River, dates back to 1837, when a report on the possibilities of the Georgian Bay route for canal construction was made by Messrs. John McNaughton and Charles P. Treadwell. The route itself had been the main highway of the fur trade from the days of Champlain, but because of its many portages was practicable only for canoes. In 1858 Walter Shanly made a report on the proposed canal for the Canadian Parliament. He estimated the cost of construction of a 10-foot waterway at $24,600,000, his plan being in general terms to cut canals at all points not already navigable, in preference to the canalization and regulation of the river. Mr. Shanly met the problem of the summit level by suggesting that the level of Lake Nipissing should be raised until it became the summit level.

Mr. T. C. Clark, who continued Mr. Shanly's work and reported in 1860, estimated the cost of a 12-foot waterway at $12,057,680, the decrease in the estimate being due mainly to the adoption of considerably lower unit prices for the necessary excavation. Mr. Clark favored where possible the use of canalized river in preference to canal. Although the feasibility of the project as an engineering problem had been established, there was much difference of opinion as to its value from a commercial point of view, and the plan was shelved for some years. About 1890 agitation in favor of the project recommenced, and Mr. T. C. Clark was again called upon to report. In 1898 he recommended the adoption of a barge canal with 14-foot depth on the lock sills. The idea of raising the level of Lake Nipissing as a solution of the summit-level problem was now abandoned on account of the growth of settlement around the shores of the lake, and Mr. Clark proposed instead lowering of the small summit lakes, Trout and Turtle Lakes, to the level of Lake Nipissing.

The project again lapsed for a time and was once more revived in 1904, when the Canadian Government authorized a complete survey. An interim report on the survey was laid before Parliament in 1908, and a final report in the following year. The Government engineering board having the matter in hand reported that a 22-foot waterway for the largest lake boats, 600 feet by 60 feet by 20 feet draft, could be built in 10 years at a cost of $100,000,000, and that the annual maintenance would be approximately $900,000, including the operation of storage reservoirs for the better distribution of the flood waters of the Ottawa River. These storage reservoirs have since been built, but the project as a whole still awaits Government approval. It may be noted that the distance from Montreal harbor to French River village on Georgian Bay is 440 miles. The rise from Montreal Harbor to the summit of 659 feet can be overcome by 23 locks, ranging from 5 feet to 50 feet in lift, and the descent of 98 feet from the summit to Georgian Bay can be made by four locks, ranging from 21 feet to 29 feet in height of lift, or altogether 27 locks, connecting 23 navigable pool levels of various lengths. Further details of the project, including estimates as to the additional cost of alternative schemes involving larger locks, and an increased

depth, different routes, etc., will be found in the report upon the Georgian Bay Ship Canal, 1909.

Projects for canals connecting the St. Lawrence and the Ottawa.—In an article in the Canadian Engineer, March 22, 1917, by C. R. Coutlee, of the Public Works Department of Canada, some interesting ideas are worked out in connection with the regulation of the Ottawa and St. Lawrence Rivers for navigation and water power. Mr. Coutlee suggested, among other things, the practicability of a ship route from Montreal via Lake St. Louis, Lake of Two Mountains, and the Ottawa River to Hawkesbury, thence across country by the valley of the South Nation River to Cardinal, on the St. Lawrence.

A somewhat similar project was suggested by Mr. Noulan Cauchon in an article in the Toronto Star Weekly, May 11, 1918. (See also Debates of House of Commons, May 18, 1918.) This was a combined irrigation and navigation project, the former to convert what is known as the Mer Bleu, a few miles southeast of Ottawa, into a great reservoir into which the flood waters of the Rideau River would be directed, creating a lake of over 30 miles square, to be utilized in irrigating a large section of eastern Ontario. The navigation side of the project contemplated the utilization of the main canal of the irrigation scheme for navigation purposes. This would give a deep waterway, 30 feet deep, from Cardinal on the St. Lawrence to the city of Ottawa, with only three locks at the Ottawa end. This project was discussed at the commission's hearing held in Ottawa in October, 1920.

Lake Superior and Lake of the Woods waterway project.—In 1906, in a report to the International Waterways Commission, Mr. J. G. Sing, of the Public Works Department of Canada, said:

> Capitalists are reported to have already proposed the canalization of the waters lying between Lake Superior and Lake Winnipeg. * * * I find upon reference to the report of the engineers who made the survey that there are 311 miles of navigable waters between the summit near Lake Superior and the Lake of the Woods, and by the proper arrangement of a series of stop-log dams and the construction of locks these waters can be fully utilized for transportation purposes. The navigation as proposed would entail very little canal work, as the cutting would not amount to more than 1 mile in the entire distance of 311 miles. * * * The total cost of opening up this route has been estimated at $1,500,000 by the engineers who made the survey.

Canals on United States side.—Waterways coming under this section on the United States side of the boundary are the New York State canal system, the Ohio State canals, the Illinois canals, and the Portage Canal connecting the Fox and Wisconsin Rivers, as well as several projects not yet developed except on paper.

New York State canal system.—The New York State canal system includes the Erie or main line, Buffalo, N. Y., to Troy, N. Y.; Champlain branch, Hudson River to Lake Champlain; Oswego branch, Oswego River to Lake Ontario; Cayuga and Seneca branch, from Erie line to heads of Cayuga and Seneca Lakes.

Without attempting to describe fully the very intricate history of these canals, it may be noted that in 1792 the Western Inland Navigation Co. was chartered by the State of New York to construct a canal connecting the Hudson River and Lake Ontario. By the end of 1796, 6 miles of canal had actually been built at and about Little Falls, to facilitate the use of the upper Mohawk, the work costing

$400,000, the State taking 200 shares of the company's stock. Soon after the Oswego River, flowing into Lake Ontario, was connected with Cayuga and Seneca Lakes. The conflicting claims of other routes held up the project for many years, and in 1808 the New York Legislature appointed a committee to consider plans for a canal to Lake Erie. Surveys were carried out, demonstrating the practicability of the route, which was later adopted. In 1810 a canal commission was appointed, which estimated the cost of a canal at $5,000,000. Financial difficulties again delayed the project, but in 1817 the legislature authorized the construction of the canal by a canal board, and the same year Gov. Clinton turned the first sod at the village of Rome on the Mohawk River. By October, 1819, the section between Rome and Utica, 15 miles, was open to navigation. In November of the same year boats from the Hudson River passed into Lake Champlain, and the following year the Erie project reached the Seneca River and was completed to Buffalo in 1825. In October of that year Gov. Clinton with a distinguished party made the first trip by boat through the canal from Buffalo to Albany, and down the river to New York. The cost up to this time amounted to something over $7,100,000. The same year work was begun on a canal 38 miles long connecting the Erie Canal with Lake Ontario at Oswego.

The capacity of the Erie Canal very soon became inadequate. It could only float boats 80 feet long by 15 feet wide and 3½ feet draft, the maximum burden being 75 tons. In 1835 the legislature authorized enlargement to accommodate vessels of 200 tons. The work went forward, and after many vicissitudes was completed in 1862, at a cost of $33,000,000. The Erie Canal was then 70 feet wide at the surface and 7 feet deep, accommodating vessels of 240 tons. In 1862 all tolls were abolished on the canal. In 1895 the legislature authorized the deepening of the canal to 9 feet; and in 1903 a much more ambitious project was authorized—that is, the enlargement of the canal to 122 feet at the surface, with a depth of 12 feet, which would accommodate boats 150 feet long. This was estimated to cost $101,000,000.

In 1909 by another referendum vote the Cayuga and Seneca Canal was added to the Barge Canal system, at an estimated cost of $7,000,000; by a third referendum vote in 1911, $19,800,000 was appropriated for building terminals for the Barge Canal at various municipalities throughout the State; and by a fourth referendum vote in 1915 the further sum of $27,000,000 was appropriated to cover the full completion of the canal system. Actual construction work on the enlarged canals was begun in the spring of 1905. It comprises the following lines or branches, all of which were opened for navigation on May 15, 1918:

	Length (miles).	Locks.
Erie or main line, from Troy Lock, in Hudson River, to Tonawanda, on Niagara River	340.68	35
Champlain branch, from Waterford (pool of Troy Dam), on Hudson River, to Whitehall, on Lake Champlain	60.70	11
Oswego branch, from Three Rivers Point, at head of Oswego River (confluence of Seneca and Oneida Rivers), to Oswego, on Lake Ontario	23.43	7
Cayuga and Seneca branch, from Erie line, at confluence of Seneca and Clyde Rivers, to Ithaca, on Cayuga Lake, and Montour Falls, on Seneca, aggregating	92.83	4

It was stated in evidence that the total expenditures on the New York State canals amounted to about $300,000,000.

Ohio State canals—Miami and Erie canal.—The Miami and Erie Canal connects with Swan Creek (tributary to Maumee River at Toledo) 1¼ miles above its mouth. The canal thence to Cincinnati has a total length of 244 miles, and the Sidney feeder branch from the south end of Loramie summit to Port Jefferson is 14 miles long. The original canal had the following dimensions: From Toledo to Junction (with Wabash and Erie Canal), a distance of 64 miles, the top width was 60 feet, the bottom width 46 feet, and the depth 6 feet. From Junction to Dayton, a distance of 114 miles, the top width was 50 feet, the bottom width 36 feet, and the depth 5 feet. From Dayton to Cincinnati, a distance of 66 miles, the top width was 40 feet, the bottom width 26 feet, and the depth 4 feet. The lock chambers were 90 feet long and 15 feet wide, and the controlling depth on the miter sills 4 to 6 feet.

The Loramie summit level of the canal is 372 feet above Lake Erie and about 516 feet above the Ohio River. There are 52 locks in the length of 123 miles from Toledo to the north end of Loramie summit, and 43 locks in the length of 100 miles from the south end of Loramie summit to Cincinnati. The canal has no connection with the Ohio River at Cincinnati, the 10 locks at this end having been cut off in 1863.

The State of Ohio in 1906 began operations for the extensive improvement of the canal by reconstructing locks, aqueducts, dams, etc.; by increasing the surface width of the canal between Dayton and Cincinnati to 50 feet (except at a few points where local conditions prevent) and the depth to 5 feet; and by restoring the original dimensions above given over the remainder of the canal. If completed according to these plans, the canal would have 60 feet surface width and 6 feet depth between Toledo and Junction (64 miles), and practically 50 feet surface width and 5 feet depth from Junction to Cincinnati (180 miles), and would admit the passing of boats 82 feet long, 14½ feet beam, drawing 4½ feet of water. No work in prosecution of the above project has been done in recent years.

The section between Toledo and Defiance, 55 miles, having a minimum width of 60 feet and 6 feet depth on miter sills, is open for navigation. Between Defiance and Cincinnati the canal is not navigable, although a portion of it is kept filled and is used as a source of water supply for industries located along its banks.

Northern division of the Ohio canals.—The northern division of the Ohio canals connects with the Cuyahoga River 4¾ miles above the lake and extends to Dresden on the Muskingum River, a distance of 149½ miles. The original canal had a minimum width of 40 feet at the surface and 26 feet at the bottom, with a depth of 4 feet. The lock chambers were 90 feet long and 15 feet wide, and the controlling depth on the miter sills 4 feet. From Cleveland to Portage summit, 35 miles from the Cuyahoga River and 395 feet above Lake Erie (at elevation 573 feet above mean sea level), there are 42 locks; from Portage summit to Dresden there are 31 locks, with a fall of 238 feet. At Dresden access to the Muskingum River is afforded by a flight of three locks, with a fall of 30 feet.

The State of Ohio in 1905 initiated work under a project for the rehabilitation of the northern division of the Ohio canals by increas-

ing the minimum width to 50 feet at the water line and 30 feet at the bottom, and the depth to 5 feet, and also rebuilding locks, aqueducts, dams, etc. The canal if finished according to this plan would admit the passing of boats 82 feet long, 14½ feet beam, drawing 4½ feet of water.

Under date of December 27, 1912, the superintendent of public works of Ohio stated that, since 1908, the legislature had failed to make appropriations sufficient to complete the work and that the funds provided have only enabled the State to improve the canal from Cleveland to Newcomerstown, a distance of 116 miles, or to within 33½ miles northerly from Dresden.

February 4, 1914, it was further reported that the floods of 1913 had damaged the canal to such an extent that the following conditions obtained: From Cleveland to Brecksville, 17 miles, the canal was intact; Brecksville to Akron, 16 miles, practically destroyed; Akron to Massillon, 21 miles, good water; Massillon to Zoar, 18 miles, no water; the next 24 miles to Dresden, a fair supply of water.

From Dresden to the mouth of the Muskingum River at Marietta on the Ohio River the distance is 91 miles, with a fall of 154 feet. This section of the river has been improved for slackwater navigation by 11 locks having 159 feet minimum available length, 36 feet width, and 6 feet depth over the miter sills. The minimum depth for the waterway is about 5.5 feet and the improvement is in good condition.

Illinois waterways.—The height of land in the upper waters of the Chicago River and those of the Des Plaines is so insignificant that in the days of the fur trade it was quite practicable at one season of the year for canoes and even boats of 6 or 8 tons to travel between Lake Michigan and the Mississippi. At other seasons of the year, however, portages of several miles had to be made. Early in the last century plans for improving this water route were transmitted to Congress.

Illinois & Michigan Canal.—The project of the Illinois & Michigan Canal dates back to the period immediately following the war of 1812, but construction was not actually begun until 1836. The canal left the Chicago River at the Forks, 5.4 miles from Lake Michigan, extended across the Portage Swamp region to the Des Plaines Valley, thence skirted the southeasterly margin of the valley to Joliet, thence along the northerly margin to La Salle, a distance of 97.24 miles, and descended 146.6 feet from low water of Lake Michigan to low water of the Illinois River. The water supply was from the lake, by way of the Chicago River, the summit level having a declivity of one-tenth foot per mile for 29 miles to Lockport. The surface of the canal was 60 feet with a depth of 6 feet. The canal had 15 lift locks and 1 guard lock 110 feet long, 18 feet wide, and 6 feet deep. The canal was actually opened to traffic in 1848. The summit level was reduced in 1866–1871. The total cost of construction was something over $9,500,000.

In 1882 it was proposed to transfer the canal to the Federal Government, but the bill covering this project failed to pass Congress in 1888. Meanwhile the Federal Government had carried out dredging in the lower Illinois River in 1852, and between 1867 and 1877 the State improved the same portion of the waterway by locks and dams.

the locks being 350 feet long, 75 feet wide, and 7 feet deep. The Federal Government completed the project between 1889 and 1893 by works at La Grange and Kampsville. The expenditure by the United States for surveys and improvements between the Chicago River and the Mississippi River by way of the Illinois River up to 1911 was over $2,325,000.

By a law effective July 1, 1917, the canal is now under the jurisdiction of the State department of public works and buildings, division of waterways, which has supervision over all waterways of the State except the Chicago Sanitary District's Drainage Canal.

As a result of the connection established between the Sanitary Canal and the Illinois & Michigan Canal, the portion of the latter between the Chicago River and Joliet is not used for navigation. Practically all boats (subject to bridge headroom) now use the Sanitary Canal and lock to the above-mentioned connection.

The 64 miles of the Illinois & Michigan Canal between Joliet and La Salle, still utilized as part of this route, has 11 locks, which will accommodate boats of the following maximum dimensions: Length 98 to 102 feet, depending upon the model; beam, 16 feet; draft, 4 feet 5 inches; and height 11 feet 2 inches above water level. Lockage and mileage toll charges in addition to an initial registration fee, are assessed on all craft navigating the canal, graduated according to character, size, and tonnage.

On May 13, 1918, an allotment of $150,000 was made by the President from the appropriation for National Security and Defense, War Department, for the restoration of the canal. During the year the locks and aqueducts were repaired and some dredging done. On September 1, 1918, the canal was opened for navigation, and at the close of the season boats drawing 4 feet of water could pass through. The special appropriation having lapsed, work was suspended June 30, 1919, the expenditure at that time being $121,793.05. At that date a depth of 5 feet in the open channel had been secured.

Illinois & Mississippi Canal.—This canal connects with the Illinois River at a point 2.75 miles above Hennepin and 13 miles below the Illinois & Michigan Canal outlet at La Salle, and extends thence in a westerly direction via Bureau Creek Valley and over the summit to Rock River at the mouth of Green River; thence in the bed of Rock River to the rapids near Milan, Ill.; and thence by canal around the lower rapids to the Mississippi River at the mouth of Rock River; total length of main line, about 75 miles. The feeder extends from Rock River at Rock Falls, Ill., about 29 miles southward, meeting the main line in mile 28. At low water the summit level is 196 feet above the Illinois River and 93 feet above the Mississippi River.

The project was adopted in 1890 and the work begun in 1892. The canal was originally intended as a link in a waterway from Lake Michigan to the upper Mississippi; it is completed and in operation. The canal has a minimum width of 80 feet at the water surface and is 7 feet deep, with locks 170 feet long. There are in operation 34 locks, built of concrete, with lifts of from 6 to 12 feet each, including a new lock giving access to the town of Sterling, which was placed in operation in 1913. Total expenditures to June 30, 1920, $1,881,896.66.

Chicago Drainage Canal.—The growth of the city of Chicago made it imperative to find a solution of the drainage and water-supply problem. The project of the drainage canal took shape in the eighties, work was begun in 1892, and the canal was opened in January, 1900. The project provided for an enlarged outlet across the Chicago divide and by way of the Des Plaines and Illinois Rivers. The flow of the Chicago River, which formerly emptied into Lake Michigan, was to be reversed and a certain quantity of the waters of the lake was to be diverted south into the Illinois River and the Mississippi. The State law constituting the Sanitary District of Chicago provided that the canal should be capable of a continuous flow of not less than 20,000 cubic feet of water per minute for each hundred thousand of the population. The canal is a little over 28 miles long, extending from the Chicago River to Lockport, on the Des Plaines River. The first 13 miles have a surface width of 300 feet and a depth of 24 feet; the remainder a surface width of 162 feet.

Accurate figures are not available as to the total expenditure on the Sanitary Canal, but it is stated by Col. J. G. Warren, in his "Report on the Diversion of Water from the Great Lakes and Niagara River, 1921," to amount to about $100,000,000. The quantity of water authorized by the War Department to be withdrawn from Lake Michigan through the Drainage Canal was 4,167 cubic feet per second. The sanitary district applied for permission to increase the amount to 10,000 cubic feet per second. This request was, however, refused because it was believed that it would substantially interfere with the navigable capacity of the waters of the Great Lakes and their connecting rivers. The matter has since been a subject of litigation in the United States Federal courts and is dealt with very fully in Col. Warren's report, elsewhere cited.

Illinois Waterway.—In June, 1919, an act was passed by the Illinois Legislature providing for "the construction, operation, and maintenance of a deep waterway from the water-power plant of the Sanitary District of Chicago at or near Lockport to a point in the Illinois River at or near Utica, and for the development and utilization of the water powers thereof." This project is for a waterway 150 feet bottom width, with a minimum depth in the earth sections of 8 feet, and in the rock section of 10 feet; the locks to be not less than 600 feet long, 110 feet wide, and with a depth of 14 feet over the miter sills. It appears from the language of the act that this waterway and the prospective water power are closely associated with the works of the Sanitary District of Chicago.

Fox and Wisconsin Waterway.—The Fox River emptying into Green Bay of Lake Michigan, and the Wisconsin River flowing into the Mississippi River, are separated at Portage, Wis., by a distance of only 2 miles, and a canal across this divide affords a navigable connection between the two streams. The early improvement was conducted by the State of Wisconsin until 1853, then by a private company until 1872, when the United States assumed control. The present improvement, authorized in 1884, provides for deepening and widening the channel of the Fox River from Depere to Portage, the depth for a distance of 125 miles between Depere and Montello to be 6 feet as low water, and for the 31 miles between Montello and Portage to be 4 feet at low water; the width of the

channel from Lake Winnebago to Montello to be 100 feet; also for construction and reconstruction of locks and dams, etc. There are 9 locks in the Fox River with minimum depth of 6 feet below Montello and 3.7 feet above Montello. A dam and a lock have been built in the Wisconsin River about 1 mile above the village of Prairie du Sac, or about 25 miles below the city of Portage, with the same dimensions as those on the Fox River, but the lift is about 24 feet. The total expenditure up to 1920 was $3,622,000.

Lake Superior-Mississippi Canal project.—In 1894 Congress made provision for examination and survey for the location of a canal connecting Lake Superior with the Mississippi by the most feasible route, either by way of St. Croix, Rum, or upper Mississippi Rivers. Two years later Maj. Sears, of the Corps of Engineers, made his report to the effect that the most feasible route was from Allouez Bay via the Brule and St. Croix Rivers. In 1900, in accordance with a further direction of Congress, Maj. Sears reported that the proposed improvement was not one which should be undertaken by the Government. In 1909 Col. Fitch, in response to a request as to whether or not the project was at that time considered feasible and practicable, reported the proposed work impracticable from a commercial viewpoint. In 1912 Congress made provision for an examination of a waterway from Lake Superior to the Mississippi by way of Allouez Bay, at the easterly end of the Duluth-Superior Harbor and the Amnicon, Moose, and St. Croix Rivers, a modification of the Brule-St. Croix route previously reported as most feasible.

The route is described as follows: Beginning at the eastern end of Allouez Bay, in Duluth-Superior Harbor; thence for a distance of 5½ miles in an easterly direction to the Amnicon River, at an elevation of 61 feet; thence for 14½ miles up the Amnicon River to a point 582 feet above Lake Superior; thence for 6 miles south across the divide, which is 630 feet above Lake Superior, to the Moose River; thence 9 miles down the Moose to the St. Croix for 149½ miles to its junction with the Mississippi River, 65 feet above Lake Superior.

The total rise from Lake Superior to the summit is 630 feet, and this point is 565 feet above the Mississippi at the mouth of the St. Croix, making a total rise and fall of 1,195 feet to be overcome between Lake Superior and the Mississippi River.

The conclusions of the engineers were that the route indicated was inferior to that previously reported on by way of the Brule and St. Croix and was not feasible from an engineering standpoint.

In 1913 the Board of Engineers was asked to reexamine and report on the route via the Brule and St. Croix. The board first dismissed a ship channel as out of the question. As to a barge canal of 6 feet depth, with 16 locks and 8 hydraulic lifts, 59 feet bottom width and 80 feet top width, and locks 170 feet by 35 feet, with 6 feet on the miter sills, it reported it commercially feasible.

(G) CHANNEL IMPROVEMENTS IN CONNECTING RIVERS.

The following statement, taken in substance from a report by Col. J. G. Warren, of the United States Corps of Engineers, gives a general survey of the channel improvements in the connecting rivers of the Great Lakes and the St. Lawrence:

Beginning at Duluth, at the western end of Lake Superior, there is ample depth and sea room until after passing Point Iroquois, at the head of St. Marys River. This river and the shoals above it are about 64 miles long and have been improved at various places throughout that length. Disregarding for the present the canal and locks at the falls of the river, the limiting channel depth and width in the river are: From Point Iroquois to the canals, a distance of 14 miles, there are six vessel courses, and the channel has a least width of 800 feet (abreast of Point aux Pins Light), with a least depth of 23 feet at low water 601.6 feet above mean sea level, except at Vidal Shoals, where the clear depth is about 20.8 feet. From foot of locks 21 feet at low water (580.6 feet above mean tide at New York at foot of locks) and 300 feet wide, respectively, through the main channel, known as Hay Lake route, to the west of Sugar Island, through Hay Lake. Between Hay Lake and Mud Lake two channels have been provided, passing on either side of Neebish Island. The West Neebish Channel, opened in 1908, passes on the west side of the island and is for the use of down-bound traffic. The upbound channel leads from the head of Mud Lake to eastward and northward of Neebish Island, traversing the Sailors Encampment Channel, Little Mud Lake, the Middle Neebish Channel, and the cut through the shallow area in lower Hay Lake. The Hay Lake route, being a comparatively straight cut, can be navigated with reasonable safety at night.

After entering Lake Huron the traffic divides, one portion going westward toward Lake Michigan and the other southward toward Lake Erie. Westward to and through Lake Michigan there is ample depth and width everywhere except at Grays Reef Passage. Southward, through Lake Huron, the width and depth are restricted at the entrance to the St. Clair River. The channel in Lake Huron has been made 2,400 feet wide and 19½ feet deep at low water, 579.6 feet above mean tide at New York. Thence the natural width and depth are sufficient for vessels of 24 feet draft at low water for 36½ miles to the mouth of this river in Lake St. Clair, where there are two canals about 3½ miles long, one for upbound traffic and the other for downbound traffic, each 300 feet wide and 20 feet deep at low water, 573.8 feet above mean tide at New York. The channel across Lake St. Clair has a least width of 800 feet and a depth of 20 feet at low water. Thence through the Detroit River the natural depth and width are ample to the head of the Fighting Island Channel, which is 800 feet wide and 23 feet deep at low water. The channel then divides, one branch, the Livingstone Channel, with a limiting width of 300 feet and depth of 22 feet at low water for downbound traffic, and the Amherstburg Channel, with a width of 800 feet and a depth of 21 feet at low water for upbound traffic. After entering Lake Erie there is ample depth and sea room to the entrances in all its harbors.

From the lower end of Lake Erie the Welland Canal connects with Lake Ontario, and there is ample depth and sea room in that lake down to its discharge in the St. Lawrence River proper. For a distance of 68 miles from Lake Ontario to Galops Rapids, the river has a fall at low water of only 1 foot, and the channel is over 30 feet deep, with a minimum width of about 500 feet. This channel is all in the United States waters except for about 7½ miles from Crossover Light through the Brockville Narrows.

At the Galops Rapids, the river has a fall of about 10 feet in three miles, with two channels having a combined cross section of about 40,000 square feet. The North Channel is in Canadian waters, navigable by light-draft boats only. The South Channel, American Galops Rapids, 4 miles, wholly in United States waters, is not navigable.

From the foot of the Galops Rapids, at Lotus (Sheldon) Island, to the head of Ogden Island, 8 miles, fall about 9½ feet, the river is confined to a single tortuous channel, consisting of three pools, 30 feet or more deep, separated at Sparrowhawk Point and Rockway Point by narrow channels, controlling depths 20 to 25 feet, having maximum current velocities of about 7 miles per hour on curves of 2,000 feet radius. The international boundary practically bisects this channel. The Galops Rapids and Swift-current Channel to Rockway Point are now overcome by navigation through the Galops Canal in Canada.

From the head of Ogden Island to the foot of Crysler Island (Bradford's Point)—11 miles, fall about 18½ feet—the river is again divided by islands into two channels. The Canadian Channel is much the larger; the upper 4 miles comprise the Rapide Plat, which are overcome by the Rapide Plat or Morrisburg Canal. The American channel is narrow and tortuous and not navigable except by small steam and motor boats. The counterpart of the Rapide Plat is known as Little River, across which there is a power dam at Waddington, N. Y., 950 feet long, to Ogden Island, heighth about 12 feet; theoretical development about 15,000 horsepower.

From Bradfords Point to Richards Bay, 7 miles, fall about 3 feet, the river consists practically of a single wide pool or channel, nearly all on the United States side of the boundary line, 30 to 50 feet deep except at the head of Cat Island, 20 to 23 feet deep. On the Canadian side, within this reach, is found the Farrans Point Canal. Descending vessels run the rapids.

Just below Richards Bay, at Tallcotts Point, the Long Sault Rapids begin and extend, including deep rapid-current channel below the rapids, for 11½ miles down to Massena Point (mouth of Grass River), with a fall of 48 feet. The American channel within this reach is narrow and tortuous, comprising the South Sault Rapids and having swift current throughout, rendering it commercially unnavigable. About 2 miles below Richards Point is located the St. Lawrence River Power Co.'s canal, 3 miles long, which diverts at maximum about 30,000 cubic feet of water from the St. Lawrence River and discharges it through a power house, head of water about 40 feet, into the Grass River, which parallels the St. Lawrence at the locality, 7 miles to mouth.

The Canadian channel within this reach is navigable only by special passenger steamers and small craft which run the rapids. The rapids are overcome by the Cornwall Canal, used by vessels both ascending and descending.

From Massena Point to St. Regis, where the international boundary leaves the river, 6½ miles, fall about 2½ feet, the United States channel is of ample width and 30 to 50 feet deep, except opposite the mouth of Raquette River, where controlling depth is 22 feet. This stretch of river is practically an arm of the Lake St. Francis pool, which lake is wholly in Canada.

The New York & Ottawa Railway Bridge, crossing at about 1 mile below the mouth of Grass River, is the only bridge across that portion of the river forming the international boundary between the United States and Canada. There are two parts to this bridge, one across the channel to the north of Cornwall Island and one across the channel south of the island. That across the south of American channel consists of three spans; the middle span is 372 feet and the two end spans are 370 feet, all from center of piers. The piers are about 12 feet wide at the water line. These spans are fixed and have 37½ feet of head room above high-water line during the season of navigation.

From St. Regis to the sea the St. Lawrence River navigable waterway is as follows:

Channel through Lake St. Francis, 30 miles, available for vessels of 14 feet draft to the head of Soulanges Canal.

The Soulanges Canal, on the north bank of the river, extends from Coteau Landing to Cascade Point, and overcomes the Coteau, Cedars, and Cascade Rapids. It is lighted by electric arc lights throughout. This canal is used by vessels both ascending and descending.

From the Soulanges to Lachine Canal there is 16 miles of navigable water through Lake St. Louis.

The Lachine Canal extends from Lachine to Montreal, and vessels lock down from it into the St. Lawrence River below the Lachine Rapids, the first rapids barring the ascent of the river.

Montreal is at the head of ocean navigation on the St. Lawrence, 1,003 miles from the Strait of Belle Isle. The St. Lawrence River Ship Channel, 330 miles, between Montreal and Father Point, has a depth of 30 feet, with a width of 450 feet in the straight portions and 600 to 750 feet in the bends between Montreal and Quebec, 160 miles, and a width of 1,000 feet everywhere in the 170 miles below Quebec. The remaining distance of 673 miles is in the broad mouth of the river and in the Gulf of St. Lawrence.

Up to 1920 the Government of the United States had spent in round numbers on ship channels connecting the waters of the Great Lakes: In St. Marys River, $9,400,000; St. Clair River, $769,000; Lake St. Clair, $2,900,000; Detroit River, $12,500,000; Niagara River, $98,000; and St. Lawrence River, $68,000.

Work is now under way by the Department of Public Works, Canada, to dredge the channel in the St. Marys River to 21.5 feet below low-water level, the existing minimum depth being 18.75 feet below low-water level. This work was carried on in 1912–1915 at a total cost of $267,000. It was discontinued in 1915 on account of the war. The only other point at which improvements in the river channels in this system of waterways has been carried out by the Canadian Government is in what is known as the Canadian Channel in the St. Lawrence River between Kingston and Brockville. This work was carried out in 1911–1913 at a total cost of something over $119,000.

(H) HARBOR IMPROVEMENTS.

The United States has improved about 90 harbors on the Great Lakes, and has spent on such improvements up to 1920 about $85,817,000. Canada has improved about 70 harbors on the Great Lakes,

at a total expenditure of about $43,508,000. Details as to the nature of the improvement, cost, etc., for individual harbors will be found, in the case of the United States, in the Annual Report of the Chief of Engineers, United States Army; and in the case of Canada, in the Annual Report of the Department of Public Works.

The total expenditure up to 1920 on rivers, harbors, and canals in the water system from Lake Superior to the Gulf of St. Lawrence by the United States was about $146,000,000, and by Canada about $194,000,000, or altogether $340,000,000. This does not include the expenditures by the States of New York, Ohio, and Illinois, or the Chicago Sanitary District.

(I) AIDS TO NAVIGATION.

Full particulars in connection with this subject will be found in the annual Lists of Lights and Fog Signals on Inland Waters, published by Canada and the United States, respectively. Reference may also be made here to the annual Survey of Northern and Northwestern Lakes, with periodic supplements, issued by the United States Lake Survey office at Detroit. Also to the Notices to Mariners published by each Government, and the various charts of the Great Lakes and their harbors issued by the United States Lake Survey office and the Canadian Departments of Marine and Fisheries and Naval Service.

It will be noted that despite the phenomenal growth of railways throughout the region tributary to the Great Lakes and the St. Lawrence, both the United States and Canada have for many years past devoted very large sums of money to the improvement of this great natural thoroughfare extending from the Gulf of St. Lawrence into the heart of North America.

COMMERCE OF THE GREAT LAKES.

Commerce on the Great Lakes may be divided into several more or less well-defined periods. First, there was the commerce of the white trader with the Indian, generally known as the fur trade. Then followed the period of pioneer settlement, differing, of course, in point of time on the different lakes. After this, but overlapping it to some extent, was the period of mineral development.

Then the period of wheat shipments from the western plains to the seaboard. Finally, we have the period of general commerce on the Great Lakes, whose development lies more in the future than in the past or present. Interwoven with this progressive development of commerce is the development of transportation, from the canoe and boat to the sailing ship and from the sailing ship to the steamboat and lake carrier, and ultimately to craft capable of carrying freight without breaking bulk from lake ports to the Atlantic seaboard and overseas.

The fur trade.—The history of the traffic of white men with Indians for furs dates back to the very beginning of European settlement on this continent. So far as the basin of the St. Lawrence is concerned it began in the days of Jacques Cartier, and followed the course of exploration westward. The earliest trading posts were about the mouth of the Saguenay. From there the trade worked

upstream to Quebec, Three Rivers, and Montreal, the latter city remaining to the end of the period of French rule in Canada probably the greatest fur market in America. Long before this, however, the course of trade had moved west, up the Ottawa to Lake Nipissing and Georgian Bay, and up the St. Lawrence to Lake Ontario, Lake Erie, and the upper lakes. Trading posts were established at Fort Frontenac (now Kingston), Fort Rouille (Toronto), Niagara, Detroit, Michilimakinac (now Mackinaw), Sault Ste. Marie, and at various points on Lake Michigan and Lake Superior, as well as in the country to the west of those lakes.

On the south side of Lake Ontario and Lake Erie, the French traders came into competition with British traders from New England, whose principal headquarters were at Albany on the Hudson. There British traders gradually worked westward until they were disputing with the French the fur trade of the Illinois country and the Mississippi. The French traders brought furs from trading posts as far west as the Saskatchewan, by way of Lake Winnipeg, Winnipeg River, the Lake of the Woods, Rainy River, and Rainy Lake, and the intricate series of small lakes and rivers to Lake Superior, thence by Lake Huron and the Ottawa route to Montreal. Furs from the trading posts on the Mississippi sometimes went south to New Orleans, but most of them, as well as those from the Illinois country, found their way to Mackinaw, Detroit, and ultimately to Montreal. The British traders sent their furs down to Albany, and thence to New York. From Montreal and New York, respectively, these rich harvests of peltries went overseas to the great markets of Paris and London.

After the cession of Canada to England, British colonial fur traders began drifting north to Montreal, and in a few years had not only carried their trading goods to all the tribes of the Great Lakes but had spread rapidly throughout the western plains, until their posts were dotted over the entire country between Lake Superior and the Rocky Mountains, and north to Lake Athabaska, Great Slave Lake, and the Peace River. These were independent traders, working alone or in small groups. In the course of time, however, the control of the fur trade became concentrated, as it had during the French régime, in the hands of powerful companies, with this difference, that while the French companies had been the outcome of colonial policy the British companies were the inevitable result of destructive competition among the traders themselves. They had to choose between abandoning the fur trade or coming together for mutual protection and profit. Out of this situation grew the North West Co., of Montreal. Certain Canadian traders who preferred to work independently organized the X Y Co., but here again the competition soon became ruinous and the new company was absorbed by the North West Co. For many generations the North West Co. disputed with the great Hudson's Bay Co. the control of the western fur trade, but this rivalry lay for the most part outside the basin of the Great Lakes. Within that basin the Canadian trading companies came into competition with the fur traders of the United States, principally the Mackinac Co. and the American Fur Co.

It would serve no useful purpose in a report of this nature to attempt to give anything like a detailed history of the operations of the

fur traders in the region of the Great Lakes. All that is attempted is to indicate very roughly the significance of this first period in the commerce of the Great Lakes. Down to the year 1821, when the North West Co. was finally absorbed by the Hudson's Bay Co., the headquarters of the Canadian fur trade remained in Montreal. Throughout the earlier period the great distributing point for the interior, and particularly for the Illinois country, was Mackinaw. With the development of trade beyond Lake Superior, Grand Portage, near the western end of Lake Superior, became the pivotal point; and when this place was found to be in United States territory the western headquarters was moved to Fort William, at the mouth of the Kaministikwia River. The American fur trade centered largely around the personality of that very remarkable character, John Jacob Astor, whose trading ventures extended from the Great Lakes to Astoria at the mouth of the Columbia. Its many feeders led to New York, as those of the Canadian trade led to Montreal.

The goods used in the fur trade of the Great Lakes came principally from England. Alexander Mackenzie gives a list in his History of the Fur Trade. There were coarse woolen cloths of different kinds, milled blankets of different sizes, arms, ammunition, twist, and carrot tobacco, Manchester goods, linens, coarse sheetings, thread, lines, twine, common hardware, several varieties of cutlery and ironmongery, brass and copper and sheet-iron kettles, silk and cotton handkerchiefs, hats, shoes, hose, calicoes, printed cottons, and other items. To a considerable extent English goods also entered into the American fur trade, although they were supplemented by articles from New York and New England factories.

These goods were made up into packages of about 90 pounds weight and carried for the most part in canoes to Mackinaw, Grand Portage, or Fort William, as the case might be. The North West Co. also had sailing ships on Lake Huron and Lake Superior to assist in carrying up the goods and bringing down the furs. At Grand Portage or Fort William the goods were transferred to smaller and lighter canoes for the long water journey to the posts of the interior. The annual value of the furs carried down by way of the Great Lakes to Montreal amounted to about $1,000,000, so that this first stage in the commerce of the Lakes reached quite considerable proportions.

It may have some significance or it may be regarded merely as a coincidence that the harvest of furs gathered not merely from the country tributary to the Great Lakes but from the vast region beyond found its way to its ultimate market to a large extent by the same natural water route from the head of the Lakes to the sea, now suggested as the most practicable thoroughfare for the infinitely more varied and more valuable products of the same immense region to-day, products the value of which has increased a thousandfold and more over those of 100 years ago.

Settlement.—The tide of settlement moved pretty steadily westward on both sides of the Great Lakes from Quebec on the one side and New England and New York on the other. Even during the French régimé in Canada there was a considerable French settlement at Detroit and on what is now the Canadian side of the Detroit River, as well as to a smaller extent at what are now Kings-

ton, Toronto, and Niagara. The colonization of Upper Canada, now Ontario, after the cession of Canada to England, consisted largely of the United Empire Loyalists, who made settlements at various points on the north shore of Lake Ontario, on the upper St. Lawrence, and in the Niagara Peninsula. Numbers of disbanded soldiers were also given grants of land in Upper Canada, and to these were added the settlers brought in by the Canada Co., the German colony in Waterloo County, and such isolated experiments as Lord Selkirk's Baldoon settlement. In these and other ways, with the aid in time of the natural increase of population, the Canadian shores of the St. Lawrence and the Great Lakes became settled from Montreal around to Georgian Bay, with subsequent extensions to Sault Ste. Marie and Fort William.

On the United States side settlement extended gradually westward along the southern shores of Lake Ontario, the Niagara River, and Lake Erie to the Michigan Peninsula, the Illinois country, and what subsequently became the States of Wisconsin and Minnesota. Settlements and territories were gradually developed out of the hinterland of the older Eastern States, and these in time became independent States.

The commerce of the Great Lakes during this colonization period was largely carried on in sailing ships, although it also saw the beginning of the period of steam navigation on the Lakes. It is not necessary to go into elaborate details as to the nature and extent of this commerce. As in the case of the fur trade, all that is attempted here is to indicate in a very general way the character of the commerce borne on the waters of the Great Lakes during these periods. Broadly speaking, the tide of settlement moved faster than the local means of subsistence, and for a generation or more the various frontier settlements were dependent for practically all the necessities of life on the older communities to the eastward, from which most of them originally came.

In an address on "The early history and condition of Wisconsin," delivered in 1856, Henry S. Baird says of the early commerce of Lake Michigan 30 or more years earlier: "Then the whole commerce of the country was carried on by means of a few sail vessels of less than 100 tons burden. The first steamer plowed the waters of Lake Michigan in 1822." This was the pioneer steamer *Walk-in-the-Water*, and the date should read 1821. It may be added that the *Walk-in-the-Water* appeared as the first steamer on Lake Erie in 1818, and that the year previous the steamer *Ontario* was launched on the lake of that name, while steamship transportation on the St. Lawrence below Montreal goes back to 1809, when the *Accommodation* was launched. The *Walk-in-the-Water* made her first trip to Mackinaw and Green Bay in July, 1821, with 200 passengers and a large cargo. The round trip took 13 days. "For several years one trip was made annually, and very rarely a second one; vessels upward bound were generally freighted, but seldom returned with a cargo * * *. Nearly all kinds of provisions were then brought from Ohio or other Western States, for little beyond vegetables was raised in the country (Wisconsin)."

Mineral development.—This and the succeeding section make up what one might describe as the bulk-freight period in the history of

transportation of the Great Lakes. Mineral development dates back to the period of French rule in Canada, when copper deposits were discovered on the shores of Lake Superior, and some slight attempts made to develop them. These deposits had been known to the Indians long before white men came to America and were used by them for the purpose of making arrowheads, etc. Early in the period of British rule in Canada further attempts were made to develop the copper deposits on Lake Superior, and a company was formed for this purpose, but because of the remoteness of the region and the lack of adequate means of transportation the project came to nothing.

It was not in fact until the tide of settlement on the United States side of the Great Lakes had begun to open up the territory south of Lake Superior that the rich copper mines on Keweenaw Point began to be seriously developed. Several companies were formed after the expedition of Gov. Cass in the thirties and forties, and in 1865 the Calumet and Hecla mines were opened. During the next 15 years millions of dollars worth of copper were shipped from these mines, and although after 1880 the Lake Superior output was dwarfed by the vast deposits found in Montana and Arizona, it continued to increase and has always been "a most important factor in the contribution of the Lake region to the wealth of the country." In 1887 the value of copper shipped by water from the Lake Superior mines totaled $6,977,200, and in 1916 the value had increased to $71,214,295. Subsequent years show a considerable decrease.

Iron ore.—It was not until 1844 that the presence of iron ore in the Lake Superior country was reported. The first discovery was made in Marquette County, Mich., in that year. Companies were formed, and the ore was shipped on sailing vessels from Lake Superior to Cleveland. Five thousand tons were shipped in this way by the Marquette Iron Co. in 1855. The enormous demand for iron in connection with the great era of railroad building after the Civil War put the industry on its feet, and production increased rapidly from year to year. For a long time only the Michigan and Wisconsin ranges were worked, but in 1875 the presence of large deposits in the Vermilion Range of Minnesota was reported, a railroad was built from the mines to Two Harbors on Lake Superior, and in 1884 the first shipments were made by water. In this year 68,000 tons were shipped; three years later the output had jumped to 400,000 tons. In 1887 the Mesabi Range began to be opened up, and together the five ranges—the Marquette, Gogebic, Menominee, Vermilion, and Mesabi—located in Michigan, Wisconsin, and Minnesota, supply to-day more iron than any single country in the world, the tonnage for 1920 amounting to 56,780,498. The total value of iron ore shipped by water from Lake Superior has increased from $8,741,995 in 1887 to $340,682,988 in 1920.

Coal.—With the development of the shipment of iron ore east began the shipment of coal from Lake Erie ports to points on the upper lakes, which, over the same period, increased from $4,735,454 in 1887 to $119,427,870 in 1920, the tonnage for the latter year of hard and soft coal being 14,156,259.

For the transport of these enormous and rapidly increasing quantities of bulk material huge steel freighters were designed, which, in the course of time, grew to 500 and 600 feet long, with a hold

whose capacity was from 6,000 to 12,000 tons, iron ore being carried on the voyage down the Lakes and coal on the return trip.

Methods and cost.—The following extract from Prof. Channing's Story of the Great Lakes is pertinent as a description of the methods and costs of bulk shipments on the Great Lakes:

> Up in the mines of Michigan and Minnesota a big steam-operated bucket dips down into the earth and scoops from the hillside a load of iron ore which it dumps into steel cars with openings at the bottom at a cost of 5 cents a ton. At the docks of Lake Superior—and the total length of the ore docks on the lake is well over 5 miles—the bottom of the car is turned aside and the whole load of red earth rushes either down long chutes directly into the holds of the vessels or into big buildings, called bins or pockets, from which it can be poured from a great height into the vessels, filling them at 15 or 16 hatches simultaneously. Such records have been made as the loading of more than 10,000 tons of iron ore into a steamer in less than an hour and a half, and the usual time for the operation is only three or four hours. The cost of this loading is made, by the use of the machinery, less than 3 cents a ton. After the swiftest passage that can be made, the vessel reaches port of the lower Lakes, and there the devices for unloading are even more wonderful. From a bridge like crane hangs a huge scoop, shaped like a clamshell, which dips down into the vessel's hold and pulls out 10 tons of ore at a time, swings it to one side, and drops it on a mountainous heap of red earth.
>
> In the interval, while the ore is being unloaded from the hold of the vessel, coal for the return cargo has been poured in, and in an incredibly short time the freighter is started on her northward journey. So successfully have time and expense been minimized by the elimination of hand labor that the freight charges on the Lakes are the wonder of the whole commercial world. Of some kinds of freight the cost of transporting a ton from Buffalo to Duluth is only 85 cents. The railroads have given up the attempt to compete and have bought up instead the lines of steamers with which they make connection. The recent tendency on the Lakes is to consolidation of ownership. To-day (1909) the Pittsburgh Steamship Co. owns a fleet of 108 vessels, whose total length if put in one line would be over 8 miles. These fleets are many times the size of those owned by Americans on the ocean. Indeed, this is one of the striking contrasts between lake and ocean traffic.

Since this was written the average tonnage of lake freighters has steadily increased.

Grain shipments.—The first record of wheat shipments through the canals at Sault Ste. Marie was in 1870, when the total was 49,700 bushels. Forty-five years later 255,481,558 bushels were shipped east by the same water route. The total for 1920 was 143,456,487. Of grains, other than wheat, the shipments in 1870 were 304,077, and in 1920, 51,630,135. Some 33,548 barrels of flour went through the canals in 1870, and 7,477,533 barrels in 1920.

Future prospects.—That Duluth and the twin cities of Fort William and Port Arthur will develop rapidly within the next few years as ports for the shipment by water of grain as well as many other commodities to the eastward there can be little doubt. The great American West, largely tributary to Duluth, is already webbed by over 40,000 miles of rail, and Fort William and Port Arthur are efficiently served by Canada's transcontinental railways. So far as grain is concerned, the ultimate capacity of the grain-growing States of the American West has not by any means been reached, and the capacity of the Canadian prairie Provinces is hardly more than touched. The next quarter of a century may see shipments of grain from these ports to Lake Superior to the eastern seaboard and to Europe many times greater than the totals recorded here.

General commerce.—Of the total of over $1,000,000,000 worth of freight carried through the canals at Sault Ste. Marie in 1920,

$119,000,000 represented shipments of coal, $86,000,000 shipments of flour, $315,000,000 shipments of wheat, $78,000,000 other grains, $6,000,000 manufactured iron, $18,000,000 copper, $340,000,000 iron ore, $10,000,000 lumber, $985,000 stone, $992,000 salt, and $125,000,000 was classed at general merchandise. This last item is, perhaps, significant of the possibilities of growth in the shipment of general merchandise on the Great Lakes, the total figures for 1887 having been a little over $20,000,000. The growth of this branch of lake commerce is more striking if one takes some of the years before the war upset all normal activities. In the four years immediately preceding the war, for instance, the total shipments of general merchandise on the Great Lakes amounted, respectively, to $212,000,000, $208,000,000, $250,000,000, and $266,000,000.

The total value of freight carried through the canals increased from $79,000,000 in 1887 to $1,119,000,000 in 1920. Records have been kept of the total commerce through the canals at Sault Ste. Marie since 1855 in terms of weight. In that year 14,500 tons were carried. In 1920 the total figures were 79,282,000, an even higher point having been reached four years earlier, when the total was nearly 92,000,000 tons.

PART III.

ANALYSIS OF TESTIMONY.

An analysis of the facts and opinions obtained by the commission at the various hearings and otherwise brought out a series of more or less well-defined arguments for and against the economic practicability of the proposed improvement of the St. Lawrence. These arguments will now be set forth and discussed as fully as their importance in each case seems to warrant.[1] It will, of course, be understood that the opinions and arguments set forth below are those of witnesses, and are not necessarily indorsed by the commission. The views of the commission will be found in Part VI.

The main points of difference between those who advocated and those who opposed the project were as to whether or not ocean-going ships could or would use the deep waterway if it were constructed; and whether or not there would be sufficient cargoes outbound or inbound to make the route a success and to justify the very considerable expense involved in its improvement. Involved in these major questions were many minor points of difference, such as the effect of the limited season of navigation on the Lakes and the St. Lawrence, ice conditions, fog, restricted channels, limited depths in inland waters, insurance rates, competition between lake freighters and ocean craft, the necessity of deepening connecting channels and harbors, harbor facilities on the Lakes and on the seaboard, the time factor as affecting voyages to and from the head of the Lakes, the possibility of developing water-borne traffic between Lake ports and Atlantic or Pacific coast ports, the possible influence of the new route in stimulating existing avenues of production and creating new ones, ship canals versus barge canals, rail versus water transportation, effect of the water route on railroad congestion, ocean rates and inland water rates, bulk freight and package freight on the Lakes, relative cost of building and operating ocean ships and lake vessels, and the characteristics of each, practicability of a composite type of vessel adapted to both ocean and lake traffic, shipbuilding on the Lakes, grain movement to the seaboard, transshipment charges and losses, natural resources of the region tributary to the Great Lakes, its industrial development, banking facilities, alternative routes to the seaboard, etc.

It should perhaps be noted that much of the evidence was more or less irrelevant in the sense that it had no particular bearing on the question of the practicability of the proposed improvement from either a negative or a positive point of view.

[1] See summary for a more detailed account of the testimony.

The object in this part of the report is to bring out the consensus of opinion on the various economic aspects of the St. Lawrence problem. It will therefore consist of opinions and statements of fact, as far as possible without comment.

OCEAN SHIPS ON INLAND WATERS.

It would serve no useful purpose to bring together here all the bald statements made at the various hearings as to the practicability or impracticability of ocean-going ships navigating the Great Lakes. These opinions may have a certain value, but it is felt to be more important to bring out the specific reasons why the negative or affirmative view is held.

As to the question of lake vessels navigating the open sea, no one at the hearings disputed the proposition that it was impracticable for transatlantic service, and particularly so far as the present type of bulk lake carrier was concerned. As a matter of fact, however, it came out in evidence that several of the obsolete type of lake freighter known as the "whaleback" had been taken out to the Atlantic and used in coastal trade. A. H. Ritter stated also that a few of the bulk lake freighters were being used for carrying coal between Newport News and New England ports. Mr. Cornelius, of Buffalo, mentioned that certain vessels his firm operated in the South American trade were in reality converted lake boats with flat bottoms. Mr. Upson, of Cleveland, also referred to a number of Canadian lake vessels that went out to the transatlantic trade on the outbreak of war; and Capt. Adams, of Detroit, quoted figures showing that 297,103 gross tons of American and Canadian lake shipping were transferred to the ocean during the war. Most of these were package freighters rather than bulk freighters. The distinction between bulk freighters and package boats on the Lakes was not always appreciated, or at any rate kept in mind, by those who testified at the hearings, comparisons being repeatedly instituted between bulk freighters on the Lakes and package freighters on the ocean, which were irrelevant, because they dealt with two quite different things.

Frank M. Williams, State engineer of New York, expressed the view that with large ocean-going ships time might be a very important element. The time factor was not material in entering ocean ports, as it was only a matter of minutes or hours, but to go up the St. Lawrence into the Lakes would involve delays running into days and weeks. Cargo ships were capable of making a speed of 10 miles an hour, but on any canalized river or artificial waterway this speed would be very materially reduced. Also the operating costs of seagoing vessels were very considerable. Further, they must earn money on a large initial cost, and long-drawn-out voyages in waters of restricted depth and in narrow channels would be bound to result in a cut in earnings, which would necessarily mean the withdrawal of these ships to lines of trade where such limitations were not encountered. He defined a restricted channel as one of such width and depth as to cause a hazard to boats operating on it, and to confine them to a very limited speed. In his view the St. Lawrence both above and below Montreal was a restricted channel.

Mr. Williams expressed the view that the proposed waterway, if it were used at all by ocean-going vessels, would be used only by the smaller type of about 2,000 tons. The most economic ocean vessel was one of about 30 feet draft, and to accommodate a boat of this size all the present lake harbors and river channels would have to be deepened to something over 30 feet.

Mr. Williams's arguments were supported among others by Capt. W. E. Chilson, Hon. George Clinton, Hon. Henry W. Hill, and Adam E. Cornelius, all of Buffalo. Capt. Chilson based his belief that it was not practicable to operate ocean-going vessels on the Great Lakes or Great Lakes vessels on the ocean, on the difference in construction of the two types of boats, the Lake boats being built for large carrying capacity and light draft with a flat bottom and very little dead rise, while the ocean-going vessels were of deeper draft for the same tonnage, which made them more seaworthy on the ocean but less adapted to the restricted depths of inland water.

Mr. Clinton compared a typical ocean carrier with a tonnage of 10,000, to the largest lake vessel. It had a draft of over 27 feet, a cargo capacity of about 350,000 bushels of wheat, and its speed was about 12 miles an hour. Such a vessel could earn 40 to 50 cents a bushel freight on grain New York to Liverpool. Its owners could not afford to send a boat of this kind up into the Lakes to compete with lake carriers that could be successfully operated for rates very much below those obtaining on the ocean. Ocean vessels could not navigate a ship canal at a speed of more than 4 miles an hour, in view of the danger of grounding, sheering, and colliding with the banks, as well as delays in locks. Also ocean vessels required a greater number of skilled officers and a much larger crew than lake vessels.

Mr. Hill added the further argument that as between ocean vessels and lake vessels, the former absorbed about 60 per cent of their displacement, while the latter absorbed only 30 or 40 per cent, and canal barges about 20 per cent. Lake vessels could carry wheat on the Lakes much more cheaply than ocean vessels, but on the other hand, they were not built to stand the storms of the high seas.

Mr. Cornelius emphasized the difference in cost of construction between ocean carriers and lake carriers. The former averaged from $150 to $200 per dead-weight ton carrying capacity, as compared with $35 to $40 for a modern lake carrier. The lake freighter carried a much bigger cargo in proportion to its tonnage than the ocean boat and operated with a smaller crew. As to the smaller types of ocean boats, he said that they had already been tried on the Lakes and proved a failure. The tendency to-day was to increase the capacity of freighters both on the Lakes and the ocean, as the larger boats had proved more economical. Lake boats also had the advantage of ocean steamers in the matters of insurance.

Mr. Cornelius differed from some of the other witnesses as to the importance of distance as a factor in the cost of voyages. His view was that it was the time in port that counted. It took much longer to unload cargoes at ocean ports than a lake port. The average time for unloading at ocean ports was seven to eight days.

Charles N. Chadwick, of New York, put particular stress upon the adverse influence of fogs and cross currents and the fact that the St. Lawrence route would be closed for six months of the year.

William A. Rogers, of Buffalo, argued that as a sea-going vessel had to carry such a large expense in overhead charges, interest, and wages it must move rapidly from port to port and could not afford to go one or two thousand miles up a restricted waterway for its cargo. He also pointed out that the shipment of grain was concentrated in a short period at the very end of the navigation season, and to handle this by water would require a very large number of ships at one time.

It was also the view of the Montreal Board of Trade, as expressed by its president, George W. Sumner; of the Montreal Harbor Commission, as represented by its chairman, W. B. Ross; of the Montreal Chambre de Commerce, as represented by its president, Joseph Quintal; and of the Shipping Federation of Canada, as represented by its president, Robert W. Reford, that, for the reasons stated, it was not economically practicable for ocean vessels to be employed on such inland waters as the Great Lakes.

Frederick H. Fay, consulting engineer, who gave evidence at the Boston hearing, stated that of 223 steel vessels under construction for the Shipping Board, not one had a draft of less than 21 feet, and the 21-foot vessel had a dead-weight carrying capacity of only 3,500 tons, while those of a draft ranging from 24 to 26 feet had a carrying capacity of from 7,500 to 10,000 tons. In his view, if the St. Lawrence projects were carried out it would have to be on the basis of a 30-foot depth from the sea up to the head of the Lakes.

At the New York hearing William McCarroll, representing the Chamber of Commerce of the State of New York, made the point that the essence of success in seaports was multiplicity and frequency of overseas shipping lines and inland transportation routes, as well as largeness of clearing-house facilities, and he held that these could not be expected at lake ports. Also vessels would go where they were able to secure cargoes in both directions, which he did not believe would be the case on the St. Lawrence route. To provide a satisfactory service between the lakes and the sea a composite boat adapted to both would have to be built, and he considered it very improbable that anyone would go to the expense of building such boats because of the cost and the unlikelihood of returns at all comparable to those obtainable elsewhere.

In the opinion of William R. Tucker, representing the Philadelphia Board of Trade, the St. Lawrence scheme was Utopian and impracticable, because even if ocean-going vessels could go up 1,500 or 2,000 miles of restricted channels it would necessarily be confined to the smaller types of vessels, and these had gone practically out of use to-day because they were not regarded as economical. Unless you had a depth to accommodate vessels of 35 to 40 feet draft you would not have the most economical carriage of goods. Ocean business was done with two classes of vessels—liners and tramps—but the greater part was handled by the former. So far as general cargo or package freight was concerned, that was almost entirely handled by liners, as tramps were not available unless they had a full cargo.

Edward R. Carhart, representing the New York Produce Exchange, emphasized the fact that it would be very difficult to concentrate cargoes at any one lake port. They would have to be

picked up at different ports, and this would involve delays. Under such conditions it would be very difficult to induce shipowners to send their boats up into the Lakes. Also the project would involve the provision of very complicated and expensive terminal equipment at Lake ports to handle traffic by seagoing vessels.

Speaking on behalf of the Philadelphia Bourse, Emil P. Albrecht was convinced that ocean vessels could not afford to use the St. Lawrence route because there would be few, if any, full cargoes from overseas points to lake ports. The commodities imported from abroad for use in the interior of the United States were for the most part not of such a character as to make full cargoes. The traffic would, therefore, be a one-way traffic, and that was very unprofitable.

On the question of insurance he had been informed by one of the marine-insurance underwriters of Philadelphia that insurance rates on the St. Lawrence were 50 cents, as against 22½ cents to Atlantic ports, and this applied at all seasons of the year. At the New York hearing Cornelius Elder, president of the Atlantic Marine Insurance Co., stated that the insurance rates, New York to Liverpool, were 25 cents, and that the corresponding rates, Montreal to Liverpool, were 27½ cents from the opening of navigation up to the middle of October, then 32½ cents to November 1, 42½ cents to November 16, and 55 cents from that date to November 25, or the close of the season. In a letter filed by Senator Hill from Chubb & Co., underwriters of New York, the first-class liner rate, New York or Boston to United Kingdom ports, was given as 12½ cents to 17½ cents. The rates for first-class tramp steamers from New York or Boston were given as 20 to 25 cents. Chubb & Co. gave the same rates from Montreal as Mr. Elder, but added that these were for first-class liners, and that the rate for tramps would be 35 to 37½ cents, with an approximate increase of 10 cents at each of the dates mentioned.

An argument that was advanced more than once, though perhaps not very seriously, against the opening of the St. Lawrence to ocean-going ships, was that it would make it possible to bring men-of-war and transports into the Great Lakes, thereby menacing cities of the United States by bombardment or other war measures.

There was what might be called, in a somewhat narrow sense, the national argument. During the Montreal hearing it was argued on behalf of some of the interests that it was not desirable from a Canadian point of view that canals in Canadian territory should be built or controlled internationally, largely for the benefit of American interests. Canals in Canada should be built and controlled by the Dominion. Similarly at New York, Buffalo, and elsewhere on the United States side it was urged that American money, needed for the development of purely American waterways, should not be diverted to an international scheme, which it was said would be mainly for the benefit of Canada. The United States had invested a great deal of money in its merchant marine, and it was therefore important to concentrate the foreign commerce in American ports. It would be better to develop the Mississippi and connect that river with the Great Lakes than to divert the course of trade through a foreign country.

Olin H. Landreth, representing the Merchants' Association of New York, summarized the various obstacles which, in the opinion of himself and others, would prevent seagoing vessels from using the St. Lawrence and the Great Lakes, as follows:

(1) The speed-retarding and dangerous element of fog and ice in the lower St. Lawrence River and Gulf; (2) shallow depths and tortuous or, at least, extremely irregular channel layout, even after improvement, necessitating very slow speeds for large vessels; (3) time lost at locks; (4) heavy marine insurance; (5) short navigation season of about seven months; (6) a largely one-way traffic; (7) a very restricted market port.

Economy in transportation, in the opinion of Frank M. Williams, demanded special types of vessels—one for the ocean, one for the Lakes, and one for the canals. No one type could supplant another in its proper waters without loss of efficiency, which would only mean increased cost of transportation. The combination of these three types of vessels in one was not practicable.

Howard J. Smith, of Buffalo, mentioned that some years ago boats had been built on the Lakes for ocean service, running from Chicago to transatlantic points, and others had operated between lake ports and Montreal, transferring there to ocean vessels. The experiment, however, had been short lived and financially unprofitable. The same thing had been tried between Buffalo and Montreal with equal lack of success.

The foregoing represents substantially all the arguments advanced against the proposition that ocean-going vessels would use the St. Lawrence deep waterway if it were established. No attempt has, of course, been made to record the views of all witnesses who at the various hearings brought forward these arguments. Those quoted above may, however, be taken as fairly representative. It will have been noted that they consist, in many cases, rather of assertions than arguments, those who opposed the improvement evidently feeling that the burden of proof rested with the affirmative.

On the affirmative side, as to the argument that ocean-going ships could not safely navigate the restricted channels of the Great Lakes, it was pointed out by Louis C. Sabin, general superintendent of the St. Marys Falls Canal, that the big modern lake freighter of 600 feet and over found no more difficulty than smaller vessels in navigating such restricted channels as those of the St. Marys River.

Capt. P. H. Uberoth, of the United States Coast Guard, corroborated the statement. In his opinion the restricted channels of the St. Lawrence and the Great Lakes offered no particular problem to ocean-going ships. More or less restricted channels were found at the entrances to nearly all the big seaports, though some were wider than others.

As a matter of fact, there was no essential difference between navigating inland channels and similar channels along the seacoast. The same methods of navigation were applied and the same lights and other navigation facilities provided. On the Great Lakes the average speed of the big freighters was 11 or 12 miles an hour, and in the restricted channels it was cut down to 10 miles an hour. The speed of the average ocean tramp was 10 to 12 miles an hour.

As to the question of time lost in passing through locks and canals, Mr. Sabin in his testimony estimated the time lost as approximately

one hour at each lock: and in the statistical report of lake commerce passing through canals at Sault Ste. Marie, 1920, it is stated that the average time lost was 1 hour and 15 minutes, which included time waiting for lockage and passage through locks and canals.

Capts. J. Hearn, John B. Mercier, and J. B. Henry, all of whom have had many years' experience navigating the St. Lawrence below Montreal, and are also familiar with navigation conditions on the open seas, testified that during the navigation season there was practically no more difficulty in bringing an ocean steamer up to Montreal than in taking her to any of the Atlantic coast ports. If you used reasonable care in navigating the St. Lawrence it was as safe as any other waterway.

Fog and ice conditions were not peculiar to the St. Lawrence. Ships were confronted with the same conditions on the routes to New York and Boston. There was no trouble with the ice during the season of navigation except in Belle Isle Strait, which, as a rule, was not used by freighters. Liners had to navigate it with caution, but Capt. Henry had traveled that way for the last 30 years and had never had an accident.

Both Capt. Hearn and Capt. Mercier gave it as their opinion that fog conditions were generally worse off the New England coast than in the St. Lawrence.

Ice conditions and fog were gone into very carefully by R. S. MacElwee and Alfred H. Ritter in their brief presented to the commission through the Great Lakes-St. Lawrence Tidewater Association, by means of a series of charts, from which it appeared that both as regards ice and fog the normal route from the St. Lawrence to Europe compared not unfavorably with the customary steamer lanes from North Atlantic ports.

Henry C. Barlow, traffic director, Chicago Association of Commerce, said that he had been out and in from New York and he had been out and in from Montreal. He had seen fogs both ways. The saving in distance by way of the Straits of Belle Isle more than compensated for any apparent difficulty in navigating because of fog. He was not aware that there were more wrecks caused by fog in the navigation of the St. Lawrence than in the navigation of the route to New York.

From his experience in navigating the Manchester Ship Canal, Capt. Henry did not think there would be any difficulty in ocean freighters going up the St. Lawrence to the Lakes. They went where they could pick up business, and there was any amount of business at lake ports. Freight carriers were accustomed to going in ballast, in order to secure a return cargo, much greater distances than to the head of the Lakes.

He did not believe there was any great difficulty in ocean-going vessels navigating canals with the equipment they had to-day. Asked as to the crew required for an ocean-going tramp steamer of 5,000 tons, he said it would be about 35 men for a coal-burning steamer and possibly 27 or 28 for an oil-burning steamer. Capt. Hearn said that the cost of operating an ocean-going coal-burning ship was not very much greater than an oil burner. The only additional equipment an ocean-going vessel would need to navigate inland waters

would be a plate put on the back of the rudder to make the vessel answer her helm more quickly.

Mr. Sabin, in his evidence at Sault Ste. Marie, gave particulars as to the time of vessels in restricted channels as illustrated in the St. Marys River, a distance of about 22 miles. The average of four steamers for three trips each going upstream amounted to 2 hours and 33 minutes. Deducting time for taking on supplies would leave a net time for the river of 2½ hours, or a speed of 8 miles an hour. Going downstream the boats took 2.53 hours, and allowing 20 minutes for supplies the running time would be 2.02 hours, or 10 miles an hour. Conditions in the St. Marys River would be approximately the same as in the upper St. Lawrence. He gave the mean running time of lake freighters for the round trip from Erie ports to the head of Lake Superior and back as 10 or 10½ miles an hour.

MacElwee and Ritter, in their brief, pointed out that as the controlling depths of 20 to 21 feet in the harbors and channels of the Great Lakes were referred to a plane of low water which was 2 feet below the plane of mean lake level, vessels were frequently able to load to greater drafts than the stated project depths of the channels and harbors. Also the high-water season was during the summer and the low-water season during the winter, so that in general there were available during the season of navigation greater depths in the harbors and channels of the Great Lakes than would appear from the statement of project depths. This led to the situation that a depth of 21 feet at the project datum plane through the connecting channels and in the harbors of the Great Lakes would permit the passage of vessels drawing 1 to 3 feet more than would ordinarily attempt to enter an Atlantic coast harbor having a similar depth at mean low water. Comparatively little diminution of speed was required for the safe navigation of restricted channels between the Great Lakes.

In regard to the upper St. Lawrence, MacElwee and Ritter took the view that navigation would not be excessively restricted. It was estimated that the total time loss in lockages and restricted channels between Duluth and Liverpool would not exceed 12 hours, and might be less. A table was inserted showing distances of open and restricted navigation and steaming time between Duluth and Liverpool. In regard to the effect of restricted channels on vessel costs and rates, the conclusion was reached that where the restricted channel constituted only a small portion of a long route, as in the present case, there was no perceptible disadvantage to commerce. To prove this contention, the experience was cited of the Manchester Canal, the Helder or Holland Canal, the Suez Canal, the Panama Canal, the Kiel Canal, and the Amsterdam Canal. In all these and other cases involving the navigation of rivers, the inland ports enjoyed the same rates as other ports on the seacoast, though the former might involve passing through restricted channels 50 to 100 miles in length. It was argued that if 5,000,000 tons of shipping were willing every year to pass by Liverpool and go up over 35 miles of canal and through five sets of locks to reach the single city of Manchester, there could be no uncertainty about the fact that a much greater tonnage would be willing to enter the Great Lakes to reach half a dozen Manchesters.

A comparison of depths at ocean ports with depths on the Great Lakes, taken in conjunction with the prevailing tonnage of ocean-

going ships, led MacElwee and Ritter to the conclusion that the deeper harbors of Europe and America had been made to accommodate the great combination liners and naval vessels, neither of which classes of ships entered into the problem of the Great Lakes, and that the maximum depth of 21 feet in Great Lakes ports would be sufficient to attract a considerable amount of ocean commerce, while a depth of 25 feet would accommodate most of the tramp commerce of the world.

In regard to the practicability of a composite boat, combining the advantages of the ocean and the lake carrier, a letter was filed from the general manager of Bethlehem Shipbuilding Corporation, to the effect that it was entirely feasible to construct an ocean carrier with a cargo capacity of 7,000 tons on a draft of 20 feet, and that the present tendency was to secure increased capacity by giving additional length and beam rather than additional draft. In the opinion of Messrs. MacElwee and Ritter, it would be a very small step in naval architecture to design an ocean-going vessel capable of carrying 10,000 to 15,000 tons on a draft of 25 feet.

A. M. McDougall, general manager of the Duluth Shipbuilding Co., expressed his conviction that a composite type of ship would not only be produced, but that it could be built as cheaply as the present types of vessels. He believed that a ship would be developed that would be in the nature of a cross between the present ocean-going tramp and the lake freighter, and that would prove economical, both in original cost and operation. He anticipated that the navigation rules would be so changed, as a result of the present shipbuilding program of the world, that there would be a gradual lessening of the amount of steel per dead-weight ton, due to the development of plans for longitudinal strength.

Capt. J. B. Henry, who had had 30 years' experience in navigating ocean ships on the St. Lawrence, thought that the best type of composite boat would be an oil-burning vessel with ballast tanks. These would decrease the draft while in the canals and increase the freight capacity to its fullest extent. This type of vessel was also economical in time and labor.

Walter S. Syrett, of the Muskegon Railway & Navigation Co., believed it was unquestionably true that special boats could and would be designed adapted to both salt water and fresh, and at no increase in cost. Any vessel of properly regulated draft equipped with condensers for sea water could operate both on the lakes and the ocean.

W. K. Greenebaum, of the Michigan City Chamber of Commerce, who had been engaged in lake transportation, gave it as his opinion that it would be quite practicable to build boats 500 or 600 feet long, with a 22-foot draft, which could be loaded with grain or other commodities at lake ports and further cargo added at Montreal to bring the draft to 30 or 35 feet. His idea was something along the lines of boats built in lake shipyards during the war, with triple-expansion engines in the stern, and built to fit in with the modern methods of handling bulk freight at Lake ports.

L. H. Johnson, of the Chamber of Commerce of Anderson, Ind., referred to the type of vessel developed by the Bethlehem Co. for bringing ore from Cuba to their Sparrow Point plant in Maryland. He believed that this was the type of vessel that would be used be-

tween the Great Lakes and the sea. Boats of this type could operate to the Lakes in summer and from Cuba to the Atlantic seaboard in winter. The vessel he had in mind was of about 6,000 dead-weight capacity and had its propelling machinery in the stern, and he believed used Diesel engines. It had the same space with numerous hatches that were found on the lake boats and was also equipped with derricks for facilitating the handling of cargoes. He thought it drew about 28 or 30 feet.

In reply to the argument that the present-day tendency was to build larger ships and discard the smaller types, tables were filed giving the draft of vessels at various Atlantic ports, which brought out the fact that while it was true that larger and larger vessels were constantly being built for ocean traffic, these huge craft were few in number, and there had been actually no increase in the average size of vessels employed in foreign trade during the last 10 years. It was shown that an astonishingly large number of the smaller steamers were used in foreign trade, and that the large vessels were so few as to exercise no pronounced influence on the average.

Maj. Gen. Black was quoted to the effect that "out of 14,513 steamships listed in Lloyd's Register for 1918–19, 81.45 per cent have drafts of 25 feet or less and 99.32 per cent draw 30 feet or less, leaving a percentage of 0.68 vessels of over 30 feet draft. This preponderance of vessels of less than 30 feet draft is illustrated by the fact that in the first six months of 1914, out of 4,476 ships which paid pilot fees at the port of New York, 4,402, or 96 per cent, drew 30 feet of water or less." A study of vessels passing through the Panama Canal showed an average draft of 21 feet, and data furnished by the Suez Maritime Canal Co. showed that the average draft of vessels through the Suez Canal was a little over 21 feet.

McElwee and Ritter asserted that it was a recognized rule of transportation that where there was a productive interior, ships would proceed as far inland as physically practicable, and the farther inland they could penetrate the greater was the resulting economy and the more extensive the area benefited. As examples of ports developed at the head of ocean navigation, they offered the following as examples: Philadelphia, 101 miles up the Delaware River; Baltimore, 190 miles up Chesapeake Bay; New Orleans, 100 miles up the Mississippi; Portland, 113 miles from the sea on the Willamette; Hankau, 615 miles up the Yangtse; Manaos, 900 miles up the Amazon; and Montreal, 1,003 miles up the St. Lawrence. From a report by Capt. Winterhalter on the Amazon River traffic, it appeared that no less than six different steamship lines had regular sailings up the Amazon, and three of these lines connected Manaos with European ports.

E. Hodson, of Hamilton, Ontario, said that it was one of the anomalies of water transportation that difference of distance did not appear to be a great factor in the establishment of freight rates. For instance, they were to-day paying exactly the same rate of freight New York to Bombay as New York to Calcutta, though the latter port was 2,000 miles farther from New York than Bombay and involved 90 miles of a tortuous river channel much more difficult than the St. Lawrence. Practically the same rates applied also to Singapore and Java. Freight charges to Manchester and Liver-

pool were identical, although the former involved 28 miles of canal with several lockages. The natural inference was that the rates on freight from Hamilton or other ports on the Great Lakes to overseas ports would not be materially greater than the rate from Montreal or any of the Atlantic ports.

H. J. Waddy, of Hamilton, gave it as his opinion that there was not the slightest trouble about operating an ocean boat in the Lakes. The present type of lake carrier could not operate successfully on the ocean, but there was nothing to prevent ocean boats trading on the Lakes. He did not mean trading from port to port on the Lakes, as they could not compete with the present lake carriers, but trading between lake ports and ocean ports. In regard to ocean rates, Mr. Waddy said that the rate to Chungking, on the Yangtze-kiang, which was nearly 1,000 miles up the river, was about the same as to Shanghai. Similarly, on this side the ocean rate from Liverpool to St. John was the same as from Liverpool to Montreal with its thousand miles of river navigation.

As to the return-load factor, while it was admitted that return cargoes were unquestionably desirable, it was pointed out by MacElwee and Ritter that the assertion that ships must have return cargoes was not borne out by the actual conditions on many trade routes and at many ports. Analyzing the foreign trade of the United States, it was shown that the trade with Europe represented exports seven times the value of imports, while imports from South America during the last 10 years had been practically double the exports.

Many vessels carrying full loads to Europe returned practically empty, while many vessels bringing full loads from South America did likewise. Considering the conditions of the Great Lakes, with the number of important ports thereon, the variety of commodities available for export, and the demand for foreign products in territories tributary to these ports, MacElwee and Ritter concluded that, as a matter of fact, a more equal distribution of imports and exports might reasonably be anticipated at ports on the Great Lakes than was now the case at the majority of United States ocean ports.

As to the objection that the proposed improvement of the St. Lawrence would necessarily involve very large expenditures in deepening harbors and providing special docks, loading and unloading facilities, etc., it was stated on behalf of many of the lake cities that they were prepared to cooperate with the Federal authorities of the two countries in deepening their harbors, and that they were also prepared to provide their ports with the most efficient equipment for handling ocean traffic. In the case of Toronto, plans for enlarging and improving the harbor and making provision for industrial and commercial development were well under way, at an estimated cost of $25,000,000. The new harbor will have a depth of 30 feet, and its docks will be equipped with the most efficient type of loading and unloading machinery. Chicago, Duluth, Milwaukee, Detroit, Hamilton, Toledo, and most of the other lake cities had already matured plans for similar harbor improvements.

In connection with harbor improvements, reference may be made to the question of good roads and trading facilities. At Detroit and elsewhere testimony was submitted as to the rapid extension of good

roads throughout the Middle Western States, and plans were outlined for connecting many inland points with ports on the Great Lakes by motor-truck services operating on these roads.

In regard to the effect of the restricted season of navigation on the Great Lakes and the St. Lawrence, it was argued that while that was obviously a disadvantage it was by no means an insuperable obstacle. Charles F. McDonald, secretary of the Duluth Board of Trade, testified that it made very little difference in the grain trade. Navigation closed nominally on Lake Superior on November 30, but extension of insurance periods usually carried it over to December 12. In normal years they received by December 10 practically three-quarters of the year's grain receipts, and after that date grain was held in the Duluth elevators for spring shipment. It was repeatedly stated in evidence by American and Canadian importers in the region of the Great Lakes that the limited season of navigation on the Lakes would not affect them materially, as they could so regulate their business as to get in the bulk of their raw materials during the season of navigation.

F. Maclure Sclanders, of the Windsor (Ontario) Chamber of Commerce, pointed to the situation on the Baltic, which carried the greatest commerce of the world in a navigation season of only seven months. In fact, as Senator Burton pointed out at the Cleveland hearing, the Great Lakes themselves offered an example of a tremendous and very profitable commerce built up on waters that were closed to navigation for several months. MacElwee and Ritter also drew attention to the fact that so far as the restricted season of navigation was concerned, alternative routes, such as the Erie Canal and the proposed Oswego Ship Canal, were or would be subject to practically the same limitations as the St. Lawrence.

Charles A. Dunning took the view that by the all-water route through shipments of grain from Fort William to Liverpool would escape the danger of blockades to which grain was always liable under the present lake-and-rail system with its transfer points on Georgian Bay or elsewhere constantly menaced by congestion.

As to the relative cost of construction of lake and ocean-going vessels, Edward Hopkins, of the Toledo Shipbuilding Co., said that lake vessels built to-day (1920) would run from $125 to $135 a ton, while ocean-going ships would run from $178 to $185. Henry C. Barlow, of the Chicago Association of Commerce, said that in a study he had made of this subject in 1912 he had found that the average cost of constructing ocean vessels was $123 a ton and of lake vessels $61 a ton. Conditions were, of course, constantly changing so far as construction costs were concerned.

As to the question of marine insurance, it was argued that this was only a comparatively minor factor in shipping costs, and it was said that in any event the figures given at New York and elsewhere to prove that insurance on the St. Lawrence was very much higher than at Atlantic ports were a little misleading, as the comparison was always made with New York, whose insurance rates were more favorable than some of the other Atlantic ports. It appeared from printed schedules of marine insurance for 1920 that the rates varied from 12½ cents to 50 cents, New York to various European ports; Boston rates were the same; Philadelphia and Baltimore ranged

between 15 cents and 50 cents; Newport News and Norfolk, 20 cents to 25 cents; Halifax and St. John, 20 cents to 27½ cents. The extreme rates for New York, Boston, Philadelphia, and Baltimore were to Mediterranean ports. Montreal rates varied from 27½ cents to 32½ cents up to October 15, with corresponding increases toward the end of the season.

Some confusion arose here, as in connection with other phases of the problem, because witnesses were not always careful to compare like things. For instance, it could serve no useful purpose to compare marine insurance rates out of New York and out of Montreal unless those rates applied to the same type of vessel, cargo, destination, etc.

Benjamin Stockman, president of the Duluth Board of Trade, brought out the point that insurance rates decreased as traffic increased, and said that the rates on the St. Lawrence and Great Lakes would depend to a considerable degree on the extent of the traffic.

James Richardson, of Kingston, Ontario, whose firm had been engaged in the grain trade for many years, expressed his belief that in time a considerable package-freight business would be developed by the smaller tramp steamers between the Great Lakes and ocean ports. It would, of course, be necessary to have deep water all the way through to the inland lake harbors. There would be no material difficulties in ocean boats navigating the Lakes. He could see no reason why a shipping business could not be developed direct from Fort William or Duluth to any place in the world where there was a market for cargo lots.

Magnus Swenson, of Milwaukee, was satisfied that if a deep waterway were provided ocean ships would make use of it. He could see no reason why ocean ships could not navigate the Great Lakes as easily at least as the long, unwieldy lake boats with comparatively small power that sailed those waters to-day. If it were possible to ship direct from Chicago or Milwaukee to Europe there was no doubt in his mind, or in the mind of the Scandinavian steamship people with whom he was associated, that ships would be glad to come into the Lakes for cargoes. At the present time Scandinavian boats were using the port of Montreal to a very considerable extent, as they saved a day's sailing as compared with the route to New York. They shipped a good deal of grain that way from Montreal to Norway. The return freights that they brought to American ports, consisting of canned fish, wood pulp, etc., were destined largely to the West and could be brought as well direct to lake ports as to New York.

C. C. West, of the Manitowoc Shipbuilding Co., submitted figures showing the estimated cost of transportation by the all-water route, Chicago to Liverpool, based on the cost of operating a moderate-sized ocean-going ship. From this it appeared that the rate per ton on cargo carriage, provided the vessel had to return light, would be $15.60; if she had to return with half a cargo, it would be $10.92; and if she could return with a full load, it would be $8.46. At these prices a shipowner could earn a moderate profit on his investment after paying bond interest and setting aside a proper amount for depreciation and a sinking fund for growth of his business. These

prices were based on package freight such as hardware, machinery, and manufactured goods. Bulk freight, such as grain, could be carried at a lower rate.

Mr. West emphasized the fact that all these estimates were based on the limiting depth of 22 feet in the harbors of the Great Lakes. With these harbors deepened the situation would, of course, be correspondingly improved, as ocean-going vessels of deeper draft would then come in and carry bigger cargoes. A uniform depth of 24 feet would accommodate vessels of 8,800 tonnage; 10,000 tons would require 26 feet; and 14,000 tons would require 28½ feet.

It was urged that the proposed waterway would have an additional advantage in opening the vast midcontinental producing and consuming region to the nationally owned commercial fleets of the United States and Canada.

Witnesses at the hearings were repeatedly asked why ocean-going vessels of such dimensions as would pass through the existing Welland and St. Lawrence Canals did not make use of them. The evidence showed that the experiment had been tried on various occasions, but the concensus of opinion seemed to be that the existing all-water route between the Great Lakes and the sea was not economically profitable under present-day conditions, because of the strictly limited tonnage that could be carried on a single voyage. That was the substance of testimony of C. C. West, of the Manitowoc Shipbuilding Co.; Edward Hopkins, of the Toledo Shipbuilding Co.; Alexander Simmons, of the Windsor Chamber of Commerce, and others. It was stated by A. H. Ritter that, as a matter of fact, there were no ocean carriers available which could navigate the present 14-foot canals with full loads. F. O. Paddock, of the Toledo Produce Exchange, informed the commission that in the early days of the grain trade they had done a large export business with small schooners and steamers by way of Montreal. Morris & Co., meat packers, had utilized one of the United States Shipping Board's steamers to send a shipment from Chicago to Liverpool. On account of the restricted depth of the canals, part of the cargo was put on board at Chicago and the remainder shipped by rail to Montreal and put on the boat there. Similar experiments with Shipping Board steamers were described by other witnesses.

E. C. Collins, of the Pittsburgh Steamship Line, gave his own experience. He had invested in 1903 in some boats of 2,000 and 2,300 tons for trade between Erie ports and the lower St. Lawrence. They struggled along for 10 or 12 years, and were finally sold to France in 1916. There was a fleet of 10 ships, light waisted, about 18 feet draft. They carried about 2,500 tons on the Lakes and 2,100 tons through the canals. They were bulk freighters. They carried steel, such as rails, billets, structural material; also a good deal of grain. They went down as far as Gaspe and brought back pulp wood for Buffalo and Erie territory. On the whole it was a very unprofitable venture.

Oliver Upson, of the Upson-Walton Co., ship chandlers, Cleveland, said that he had fitted out four ships built on the Lakes about 1900 to carry goods between Chicago and Hamburg, principally for the International Harvester Co.'s business in grain. Only one of those boats came back to Chicago, and then went down to New York. Since then all four had remained on the ocean. The failure of that

venture was due to the cost of operating through the canals. The ships were built so close to the dimensions of the locks that they were damaged going through. That and the loss of time and heavy insurance premiums made it an unprofitable venture.

Ten ships had also been fitted out to carry grain from Duluth to Quebec. They operated one season and then got into the Chicago and Montreal trade, and continued there until taken over by the Government at the beginning of the war. One was wrecked on the Montreal service, and after being salvaged was operated on the Fort William-Kingston route. In his opinion, all these boats had been built wrong, with their passenger quarters aft below decks and with water-tube boilers, which were not safe on ships. None of these boats made much money. The boats in the Canadian service between Fort William and Montreal were built abroad for the most part. They were able to make money because of low cost of operation. They broke even during the summer and made money in the spring and fall.

About 10 or 15 years ago there was an influx of Norwegian ships into the Great Lakes. None of them made more than one trip, loading cargo at Chicago, Cleveland, and other ports. It was apparently an experiment. They also had one Swedish ship. There had been perhaps 15 or 20 ships built in Canada for Welland Canal service and the St. Lawrance. They all went into the transatlantic trade as soon as war broke out. Very few of those ships, if any, had come back.

He believed about the only fleet of small boats that was making any money on the Lakes was owned by a company of which he was one of the directors. They had specialized in the coal business from Lake Erie to the St. Lawrence. The only other small boats that had made any money were those of the George Hall Coal Co., which traded down to Montreal, Lake Ontario business exclusively. Two or three boats had been tried in the package business from Montreal to Cleveland and Toledo. They brought stuff up from New England by way of Montreal. They tried it one season and then sold the boats. The 14-foot St. Lawrence canals had not been a success in developing trade.

Henry C. Barlow, of Chicago, not content with offering testimony to disprove some of the arguments against the practicability of bringing ocean ships up into the Lakes, offered an entirely new argument for the affirmative. He said that there was a distinct advantage in bringing ocean vessels long distances in fresh water as it completely cleaned their hulls. He had found that vessels coming up the river to New Orleans, 180 miles of fresh water, cleaned their hulls completely except of barnacles, and that increased their speed perceptibly and correspondingly reduced the consumption of coal. Gen. Goethals had told him that the same thing was true in the short distance of the Panama Canal. The benefit would be even greater for a vessel coming up to the head of the Lakes.

RAILWAYS VERSUS WATERWAYS.

Testimony admitted at the hearings brought out a number of points of contact between waterways and railways, and, more specifically, between the Great Lakes and the proposed deep waterways and those railways connecting the mid-continental area of the United

States and Canada with the Atlantic seaboard. One of the outstanding facts of the evidence was the existence, particularly on the United States side, of serious congestion, both on the railways and at their Atlantic tidewater terminals. The fact of this congestion was not seriously disputed, but there were differences of opinion as to the causes and also as to the remedies. In particular, many witnesses at hearings in the eastern American cities denied the argument advanced by those who testified at western hearings that the St. Lawrence waterway offered an effective means of relieving congestion both on the railroads and at the Atlantic terminals.

Before attempting to analyze the testimony as to congestion, car and locomotive shortages, terminal facilities and deficiencies, rail and water rates, rail and water connections, transshipment problems, the time factor, refrigeration, etc., it will be convenient to introduce here a statement by Julius H. Barnes, filed by R. H. Faxon, at the Des Moines hearing, with particular reference to the flexibility of water as compared with rail transportation. Mr. Barnes in the statement in question referred to the striking lessons as to the value of water transportation obtained out of our war experience. The flexibility of water transportation had been brought sharply into notice by the work of the relief commission after the armistice. If one looked at the map of Europe it would be seen that to Vienna it was only a short rail haul from the Adriatic port of Trieste. Yet when we came to feed Vienna, where 3,000,000 were on the verge of starvation, it was found that the rail line could not handle the traffic. The line of least resistance was through the port of Hamburg and by water transportation up the rivers of Germany. Mr. Barnes emphasized the point that the great merit of water transportation was not only its cheapness but its capacity for immediate and indefinite expansion.

So much evidence was submitted by so many witnesses in regard to congestion on the railroads that it is impracticable to do anything more than indicate its general trend. Carl D. Jackson, chairman of the Wisconsin Railroad Commission, who had had unusual opportunities for getting into touch with the transportation needs of the country, said that the State railroad commissions had been cooperating with the Interstate Commerce Commission in the effort, not to get through all the freight, which was an absolute impossibility, but to get through the most vital and necessary freight. It was impossible to exaggerate the critical condition of freight business in the United States to-day (1920).

Mark Mennell, of the Mennell Milling Co., Fostoria, Ohio, said that an analysis of the package goods situation showed about five times more tonnage available for export than the total capacity of the Atlantic and Gulf ports; so that only one-fifth of the tonnage could move and that under greatly congested conditions. So far as the effect of car shortage and congestion on business was concerned the experience of his own firm was that on January 1, 1920, they had entered the new year with a hundred per cent capacity of their plant sold, much of it for export, but up to June 1, they had only enjoyed 10 per cent operation; 90 per cent of the time they had been shut down because of lack of transportation.

H. G. Taylor, chairman of the Nebraska State Railway Commission, referred particularly to the effect of congestion on the grain

situation. He was of the opinion that taking wheat and corn together probably 20 to 25 per cent of the 1919 crop was still on the farms or in the State elevators. It had been the practice of the railroads six or eight years ago to accumulate cars in that territory late in May and early in June in anticipation of the crop movement, and 6,000 to 10,000 cars would be stored on the sidings and put in repair. The congestion and volume of traffic had, however, been so great in recent years that no such preparation could be made for the movement of grain. To-day instead of a surplus of cars they were confronted with a shortage for the actual movement of the 1920 crop while part of the 1918 crop was still waiting to be moved.

Hon. Charles A. Dunning, provincial treasurer of Saskatchewan, referred to the grain blockade in the western Canadian Provinces. There had been no serious blockade for several years, but that might very well have been because the crops were below normal. There had, however, been tremendous increases in acreage and agricultural development generally and there was grave fear that the first normal crop might bring about the worst blockade western Canada had yet experienced, because railroad transportation facilities and outlet facilities had not begun to keep pace with the development of the country.

J. W. Shorthill, of the Nebraska Farmers' Elevator Association, gave it as his opinion that the transportation situation was not merely one of the most discouraging things with which the farmer had to contend, but it was the most discouraging thing. He would not except labor conditions or prices. The shortage of cars at the present time (1920) throughout the country amounted to something like 225,000. There was also a large shortage of engines to move the cars. But he was not yet persuaded that if they had all the cars and engines they needed at this moment the transportation situation would not be even worse than it was, because the more cars were pushed into a congested area and up to congested harbors the worse the condition became. They were faced with those physical limitations, and some way around must be sought. In the West it was not so important what it actually cost to move a commodity as it was to have the opportunity to move it at all.

George Mantor, secretary of the Commercial Club of Aberdeen, S. Dak., said the transportation situation in 1920 was so serious that they were no longer looking for reduced freight rates but rather for transportation at any cost. There was a complete breakdown of the rail system. In his own business sheet copper had been ordered by express from New York six months ago and had not yet arrived.

F. O. Simonson, assistant director of markets of South Dakota, stated that the crippled transportation service had meant the loss of thousands of dollars to the farmers of South Dakota during the last two or three years. Firms had been forced into bankruptcy on account of their inability to secure cars in which to ship the live stock they were handling.

F. C. O'Brien, traffic manager of the Allis-Chalmers Manufacturing Co., Milwaukee, said that his firm, like others, had suffered from the prevailing congestion. Their machinery shipments had been held up for from 60 to 90 days. Since 1914 the railroads of the country had actually increased their equipment by about 1 per cent, while the business of the country had grown 50 per cent.

Charles Murray, president of the Toronto Board of Trade, gave it as his experience that it had taken weeks to get material to Toronto where formerly it had only required days. There had been congestion in every direction. He admitted, however, that conditions had improved since the close of the war.

C. B. Heineman, secretary of the Institute of American Meat Packers, testified that traffic congestion had existed for a number of years on practically every railroad line east of the Indiana and Illinois State line.

B. R. Inman, manager of the Indiana State Chamber of Commerce, gave as a typical illustration of the effects of congestion on the railways the experience of an Indiana firm which manufactured 80 per cent of the glass fruit jars of the United States. In response to appeals of the United States Government to conserve food, the housewives of the United States had gone in extensively for canning local fruits. They depended upon this firm for their jars. The latter had their warehouses filled with 800 carloads of these jars to supply the local grocers. This required 150 cars a day during the period immediately preceding the canning season. They applied for these cars, and the best the railroads could do, even after pressure by the Interstate Commerce Commission and other public bodies, was to supply 17 cars a day. Personal appeals were made to Washington, and finally, after three trips, the supply of cars was raised from 17 to 77 per day. In this one instance the saving or loss of millions of tons of foodstuffs depended upon these cars.

MacElwee and Ritter in their brief, under the heading "Transportation shortage," brought together a great deal of evidence as to congestion on the railroads of the United States and its effect on the industrial life of the country. They discussed the inadequacy of the railroads, comparing by means of a table the actual and normal freight traffic in ton-miles for a period of years carried down by means of estimates to the year 1926. The total needs of the railways of the United States during the next three years were stated as a total of 712,000 cars, which would involve an expenditure of approximately $2,000,000,000. Another table revealed the progressive reduction in new mileage constructed, and this was shown to apply also to the construction of yards, stations, and all terminal facilities as well as locomotives.

So much for the existence of congestion and its effect on commerce. Then as to the causes:

Rear Admiral W. S. Benson, chairman (1920) of the United States Shipping Board, gave it as his opinion that the failure of the railroads to meet the situation which had confronted them had been due not so much to their inefficiency and disorganization as to the fact that the load had been too heavy for them to carry.

J. L. Record, of the Minneapolis Steel & Machinery Co., expressed the view that the roads between the West and the East had reached the point of diminishing returns. In other words, the burden they had to carry had reached the point where they could only be helped by relieving them of some of the low-rate traffic.

F. O. Paddock, of the Toledo Produce Exchange, said that the inefficiency of the transportation system was not merely the result of war conditions—in large measure it was simply the inability of

the railways to keep pace with the development of the country. It would probably take seven or eight years for the factories and engine works to furnish the equipment actually needed to-day.

Mr. Barnes emphasized the same point, that congestion was not by any means a purely war condition. The structure of freight movement for export was such that commodities originating on western lines were thrown onto the eastern trunk lines for delivery at seaports in excess of the train tonnage, and this situation became acute during the crop movement. In other words, there was a total lack of balance between the flow of commodities to the eastern Atlantic seaboard from the West and the return tonnage which should send those cars back into service.

And as to the remedy, Mr. Barnes's view was that there was only one effective remedy. Until this condition was corrected the West would always have an inadequate car supply from the time the grain commenced to move until that movement terminated. The remedy was to admit the ocean-going fleet to the producing section through the Great Lakes and at the same time to permit the lake carriers to proceed with their cargoes to the seaboard.

If the cars from the harvest fields terminated their voyage with foreign-bound grain at the western lake ports they would be retained on the lines which provide them; their carrying capacity would be enormously increased; the normal balance of car supply on the eastern and western lines would be preserved, and every business in the country would be relieved at once by a more equal and just flow of car service.

This was substantially the view of all those who discussed the question at the western hearings, and notably of experienced railroad men, such as George W. Holdridge, J. W. Hannaford, and E. Pennington. MacElwee and Ritter pointed out that car shortage was not the only trouble. New cars would not relieve the congestion at the gateways and terminals but on the contrary would tend to still further aggravate the situation. There was only one real solution of the problem attending the movement of peak loads and that was the opening of new routes to relieve the existing ones of the surplus traffic.

Statements were made at some of the eastern hearings on what may for convenience be called the opposition side of the question.

Peter G. Ten Eyck, of Albany, believed that the existing congestion was very largely due to conditions arising out of the war, and that it would correct itself in due time. The railroads of the country would gradually catch up with transportation requirements.

John N. Cole, commissioner of public works of Massachusetts, expressed the opinion that if the same amount of money proposed to be spent on the St. Lawrence route were devoted to the improving of terminal facilities at Atlantic ports, and if the existing water transportation facilities were coordinated with the railways, the country would have splendid service.

William McCarroll, of New York, while recognizing the inability of American railroads and waterways to give adequate service during the war period, did not believe that the proposed waterway would afford any genuine relief. That relief could only come by the improvement and enlargement of existing and long established routes

of commerce which had been created by the operation of fundamental economic laws, and the improvement and enlargement of those routes was already under way and would be made available long before the St. Lawrence project could possibly be completed.

Charles M. Chadwick, of New York, argued that the demonstrated inefficiency of the railroads would be cured by the provision of adequate terminal facilities and the unrestricted use of the New York Barge Canal.

William R. Tucker, of Philadelphia, said that it was a mistake to suppose that with proper equipment and working under private management the railroads could not carry the produce of the country. He had not the least doubt that in conjunction with the other methods for the transfer of goods they would be able to care for all the traffic offered.

Nisbet Grammar, of Buffalo, gave it as his opinion that in two or three years the railroads would be in as favorable a position to move the traffic of the country as they had been in the summer of 1914, which would mean real transportation. His solution of the transportation problem was to treat the railroads more generously, give them very much higher freight rates, and allow them time to get new equipment, to put their tracks in order, and also to get control of their labor and change it back into a loyal group of employees. Under these conditions he believed they would get back efficient railroad service and in no other way.

In regard to existing facilities at terminals on the Atlantic seaboard, and their ability or otherwise to meet existing requirements, some of the evidence submitted related to Atlantic terminals generally, but the greater part was directed to the situation at the port of New York. One or two references were also made to congestion at the Gulf ports.

Ralph P. Bolton, secretary of the greater Des Moines committee, took the linseed-oil business as an illustration of the intolerable difficulties American business interests had to face in getting their exports and imports through the port of New York. He pointed out that all but five of the flaxseed mills of the country were located in the Great Lakes district. Owing to the fact that flax was a new-land crop the production in the United States and Canada had steadily fallen off and the American mills now had to go to the Argentine and Manchuria and to India for about 20,000,000 bushels of flax. This was shipped through New York and stuck there. Some flax mills had had to pay $2,500 a day demurrage charges on vessels, because it was impossible to get the flax unloaded. Mills had to close down because they could not get their material. The unloading facilities at New York were primitive. The only improvement they had had in 100 years was the substitution of the steam crane for the old block and tackle.

R. S. MacElwee gave specific examples illustrating the expense and delays involved in getting shipments through the port of New York. The congestion at that port had no doubt been aggravated by conditions arising out of the war, but congestion was there before the war. The situation at that port was the inevitable result of the enormous increase in the foreign commerce of the country with no corresponding increase in the facilities at New York for handling that commerce.

E. A. Kersten, of the S. S. Kresge Co., Detroit, stated that in their business they handled fifteen to sixteen thousand different articles on their counters with a business amounting to over $50,000,000 a year. A great deal of their material was imported from abroad. They had found that the average time consumed in getting merchandise from Europe or Japan through the port of New York to Detroit was four months, one month of which was used in the port of New York.

Lee H. Bierce, secretary of the Grand Rapids Association of Commerce, described the difficulties experienced by Michigan shippers in getting exports through New York. These difficulties were so serious that they had to send a man with each shipment to see it through the port.

Henry C. Barlow, of Chicago, has not much faith in New York being able to improve her terminals so as to take care of the ever-growing commerce of the country. They had not done it in the past, they were not doing it now; and he doubted if it ever would be done unless the Federal Government did it for them. There had been talk of $100,000,000 or $200,000,000 improvements to New York Harbor for a great many years, but they had not materialized. Commenting on the suggestion that it would be more in the national interest that the Government should spend money on the improvement of terminals in New York Harbor than on the St. Lawrence waterway, he said that it had been the policy of Governments from time immemorial to improve waterways at the public expense, but it had never been their policy to build private docks and private warehouses for private individuals.

C. T. Bradford, traffic manager of the International Harvester Co., said that his company had found it necessary to maintain a special organization in New York to expedite the forwarding of their goods, but in spite of that it was not at all unusual for goods to be from 60 to 75 days from date of shipment from Chicago to date of clearing from New York.

Carl W. Brand, of the Widler Co., Cleveland, said that delays in getting shipments through New York had resulted in importers having to carry a much larger investment in their business. In some cases the cost of handling goods through New York amounted to 20 per cent of the first cost. He did not believe that prewar conditions would ever return to the port of New York. Commerce was too great. The only solution was to develop other avenues.

Other witnesses at the various hearings gave specific instances as to the losses in time and money experienced by shippers in getting their goods through the port of New York.

E. S. Westbrook, of the Omaha Grain Exchange, stated that congestion at Buffalo was just as bad as it was in New York. Owing to the very serious congestion at the seaboard they could at the present time get from 10 to 12 cents a bushel more for wheat put on board vessels than if it was merely delivered at the seaboard. That was the measure of the risk due to congestion.

Walter L. Ross, of the Toledo, St. Louis & Western Railroad, said that his railroad experience of 30 years had convinced him that the primary cause of most of the transportation difficulties had been congestion in New England and New York. The waterway project, involving the establishment of a number of ports on the Great Lakes, would in his opinion relieve the New York and New England and

Maryland ports situation very materially, and that in turn would make for increased efficiency in transportation all over the country.

Dr. MacElwee, in discussing terminal charges, said that few persons realized what a burden these charges had come to be upon both the domestic and foreign commerce of the United States, affecting the high cost of living at home and limiting the markets for American products abroad. The point of diminishing returns was soon reached with an increase in the size of the terminals; that is, beyond a certain size terminal costs increased rapidly with the further increase in size of the terminal. It was therefore a natural conclusion, unfortunately borne out by fact, that the greatest terminal in the United States, New York, was the most expensive and the charges there rested most heavily on commerce.

The Ports Facilities Commission of the United States Shipping Board had gone into the question of the charges borne by steamship companies at New York. The actual physical loading of the vessel was not the great source of loss and expense to-day, but rather the time the vessel was held in port. The case was cited of a small steamer of 6,450 dead-weight tons which was 15 days in port discharging 2,713 tons and loading 3,783 tons of general cargo. The port pay roll, supplies, interest, depreciation; hull, marine, and other insurance; charter hire, etc., amounted to $42,286. Other expenses such as wharfage, pilotage, and the various stevedoring account amounted to $23,385, altogether $65,671, or an average of $4,371 a day. Hamburg, Rotterdam, and a few other of the efficient ports of Europe could have easily dispatched this vessel in five days before the war. On that basis the delays were costing nearly $5 a ton to the ship.

Charles W. Baker, of New York, testified that some 10 years ago he had made a special study of the relative costs at terminals and between terminals. At that time between New York and Philadelphia the cost of handling at the terminals up to the time the shipment was ready to start on its journey was fourteen times the cost of handling it over the road. To-day the relative cost would show a much greater difference between terminal charges and hauling charges. That was why the St. Lawrence waterway would be one of the most profitable enterprises ever undertaken. It would eliminate cost of handling freight in the most expensive terminals in the world—those on the Atlantic seaboard.

Magnus Swenson, of Milwaukee, in discussing the difficulties in getting shipments through the port of New York emphasized the losses through pilferage. In his experience this had developed into systematic robbery. A great many of their case goods were broken into at night, and when they reached their destination packages that, for instance, should be occupied by sardines were found to be occupied by bricks. Another point made by William Stone, chief deputy collector of customs at Cleveland, was that as a general rule the greater the volume of business at a customhouse the longer time it took to get the goods through. This was accentuated in the case of New York. At the smaller customhouses of the country they were able to make expeditious clearances. He described the vexatious delays experienced in getting goods through Atlantic ports for interior points.

Attention was also drawn by E. S. Westbrook, Mark Mennell, and others to the unsatisfactory port facilities on the Gulf.

On the other hand, Murray Hulburt, commissioner of docks and director of the port of New York, argued that if there was congestion and inadequate terminal facilities at New York, the fault lay largely with Congress, which had proposed improving the East River under a plan adopted in 1868, the Hudson under a program adopted in 1875, and the Harlem under one adopted in 1879. He stated that the city had finally succeeded in inducing Congress to adopt legislation which would insure a 40-foot channel throughout the entire length of the East River and in the Hudson from its mouth to the center limits. The Army engineers were also making surveys for the further improvement of the Harlem.

He described the plans of New York for harbor improvements, including 12 mammoth docks on Staten Island to be completed within a year, which in his opinion would give New York the most modern and efficient terminal in the Western Hemisphere if not in the world. The city was also preparing plans for the reconstruction of the antiquated docks on the Manhattan side of the North River. Mr. Hulburt also referred to the comprehensive plan for the unification and development of the port of New York embodied in the report of the New York and New Jersey Port and Harbor Development Commission, portions of which have since been filed with this commission.

Nisbet Grammer, of Buffalo, Senator Hill, and other witnesses expressed the view that with the completion of the plans now in contemplation the port of New York would have no difficulty in handling the commerce of the country.

Another point as to which evidence was submitted related to the expense and losses involved in transshipment of grain and other commodities. So far as grain was concerned, Mr. Irving Delamater, of Fort William, pointed out that under the present system a bushel of Canadian grain was handled once at Fort William or Port Arthur, twice in the eastern public elevators, and twice at the seaboard. With a through waterway four of these transfers would be eliminated and four transfer charges saved. The grain would be delivered in better condition and more quickly than at present. There would also be a saving in insurance charges. Transfers involved shortages varying from 100 to 3,000 bushels per steamer. There was also the waste resulting from transfers through elevators due to erosion in handling. This had been estimated by experts as an average loss of 30 pounds in every 1,000 bushels of grain.

Charles N. Candee, of Gutta Percha & Rubber (Ltd.), Toronto, also drew attention to the disadvantages of transfers in broken packages, injury to goods, and pilfering. The fewer the transshipments the better shape goods would reach their destination. This applied to practically all package freight.

L. H. Boughman, of Toledo, testified to the same effect. Under the present system of transportation, with the various handlings they had to go through, it was almost humanly impossible to pack their goods so that they would not arrive at their destination more or less broken.

Watson S. Moore also discussed other features of the transfers between interior points and the seaboard, such as hazards of strikes

and industrial disorders and embargoes which forced the buyer to add an extra item to insure himself against loss. He also referred to loss and dissatisfaction resulting from differences in grading wheat at the western inspection and seaboard inspection.

A great deal of testimony was submitted on the question of rail rates and water rates and the relationship between the two. In a statement filed by A. C. Lewis on behalf of the Canadian Deep Waterways and Power Association it was stated that an all-water route from the head of the Great Lakes to Europe would at once result in a saving of at least 5 cents per bushel on wheat shipments for Europe and a saving varying from 60 to 30 per cent in freight tariff on imports destined for points between the head of the Lakes and the Rocky Mountains. The Interstate Commerce Commission was quoted to the effect that water transportation of freight cost only one-tenth as much as transportation of freight by rail.

W. F. Kerwin, traffic expert, of Green Bay, comparing rail and water rates, pointed out that the present rates on hard coal by rail from Buffalo to Menominee was $2.65 a ton while the normal boat rate on coal between the same points was about 40 cents a ton.

A. D. Kelley, of Cheyenne, argued that the saving in transportation rates, as far as the State of Wyoming was concerned, would be equal to 6 cents a bushel on wheat and 5 cents a pound on wool going to foreign markets.

Charles F. MacDonald, of the Duluth Board of Trade, testified that the lake rate on grain from Duluth to Buffalo was at the present time 4 cents a bushel, and the transportation from Duluth to New York, including lake-and-rail rates with insurance and incidental charges, was about 15½ cents a bushel. That was delivered in New York but not on board vessel. The all-rail rate from Duluth to New York at the present time was 20.7 cents, and if railroads were granted the advance in rates they were now asking the cost of delivery by lake and rail would be approximately 18½ cents and by all rail 27½ cents.

At the present time there was very little movement of grain by the all-water route to Montreal, but with deeper channels so that large vessels could move direct from the head of the Lakes to Montreal, the rate would be about 11 cents, which would be 4½ cents better than the lake-and-rail route through New York, and 7½ cents better if the railroads were permitted to increase their rates. The lake rate of 4 cents was fairly constant, depending upon competition between grain and other tonnage. If anything, that was a little higher than the normal rate.

C. A. Rowe, of the Marshall-Wells Hardware Co., said that a comparison of westbound freight rates on articles of iron and steel showed that they were at present paying from New England to Duluth on hardware in less than carload lots, all-rail, $1.07½ per 100 pounds; rail-and-lake, 69 cents per 100 pounds; on carload shipments, all-rail, 65 cents, rail-and-lake, 41 cents. On the same shipments, by the all-water route, he figured that a rate could be made of perhaps 50 cents per 100 pounds in less than carloads and 25 cents in carload lots.

F. S. Keiser, traffic commissioner of Duluth, said that as the result of some very exhaustive studies he had found that the approximate

cost of package freight by lake and by rail was about in the ratio of 1 to 12. That was based on data brought down to 1912. In that year the cost of handling 1 ton of freight per mile by rail was 5.71 mills, whereas the cost of handling the same by boat was 0.67 mill. He thought it would be fair to say that the cost of handling package freight by water to-day would be approximately one-half mill per ton per mile, whereas the rail rates were not less than 10 mills per ton a mile; the ratio to-day would therefore be about 1 to 20.

In regard to the question as to how far inland rates to the Atlantic coast would be published if the proposed water route were established, Mr. Keiser said that he had made some investigations and found that there were rates published from all points located just east of the so-called western terminal line; that is, an imaginary line drawn from Buffalo to Pittsburgh, to Wheeling, and to the Virginia-West Virginia State line. All territory east of that line was known as Atlantic seaboard territory. With the new route established, he believed that through rates would be published not only from Atlantic seaboard points but from Pittsburgh and the western terminal line for transportation by water to the head of the Lakes and distribution throughout the West.

O. P. B. Jacobson, of the Minnesota Railroad & Warehouse Commission, said that at the present time the lake-and-rail rate from Minneapolis to New York via Duluth and Buffalo was about 26½ cents per 100 pounds. The rate from New York to Liverpool varied greatly, but at present averaged about 25 cents per 100 pounds, making a total of about 52 cents from Minneapolis to Liverpool. He argued that the saving in transportation rates by the all-water route plus the cost of transfers would be equivalent to a saving of from 10 to 15 cents a hundred pounds, which would give the West a tremendous advantage in competing with the Argentine and Australia for the grain trade of Liverpool, Rotterdam, and other foreign markets.

Hugh J. Hughes, market director of the Minnesota Department of Agriculture, figured that the cost of transporting a bushel of wheat from Duluth to Buffalo was $0.0225. At Buffalo the transfer charges from boat to rail were approximately $0.0075. The rail haul from Buffalo to New York amounted to $0.04, and the cost of transferring from car to ship in New York Harbor $0.003. Freight charges under normal conditions from New York to Liverpool were $0.0525, making a total transportation charge from Duluth to Liverpool of $0.1255. Deducting the three items involving transfer and rail haul amounting to $0.0505, there was left a total water haul charge of $0.075. In other words, fully one-half of the total transportation charges from the terminals at Duluth to the warehouses in Liverpool was taken up by an overland portage that left the bushel of wheat when in New York Harbor farther away from its point of destination than when it left the ship at Buffalo. Assuming the creation of a deep waterway from Duluth to the sea, it seemed apparent that the shipper would save an amount equivalent to the cost of transportation from lake boat at Buffalo to ocean-going ship at New York.

James E. Home, of Toledo, offered a comparison of cost on pork products, Toledo to Liverpool, via rail to Montreal and transshipment there to ocean steamer as against an all-water shipment Toledo

to Liverpool. Balancing the charges by the two methods, he found that the rail and water charges amounted to $465 on 40,000 pounds and the all-water charges would amount to $402.

Alex Simmers, of the Windsor Chamber of Commerce, pointed out that prior to the deepening of the Soo Canals grain from Fort William to Georgian Bay ports and Sarnia was charged as high as 15 cents a bushel, and coal from Cleveland to Fort William paid $3.50 a ton. The deepening of the canals to 20 feet reduced grain charges to an average of 2½ cents a bushel and coal to 50 cents a ton. Similarly striking savings could be shown on other commodities. He estimated that on the two items of grain and coal alone Canada had effected an economic saving of $24,750,000 by her investment in the canal at Sault Ste. Marie. He asserted that the entire expenditure of Canadian public funds on the Soo Canal was returned in full to the public every year in the form of reduced freight rates.

Comparing the rates on grain and coal between Erie points and Duluth and Fort William through the 20-foot Soo Canal, and from Erie points to Montreal through the 14-foot canals, he argued that the annual saving in freight charges on this local traffic alone, following the widening and deepening of the Welland and St. Lawrence Canals, would make it a profitable investment.

He argued that the Great Lakes and their connecting links in the shape of canals and rivers had always been the determining factor in the application of railway rates in North America. To illustrate this he compared rail rates Fort William to Winnipeg, where no water competition was possible, with rail rates Montreal to Fort William, where there was water competition. The same thing applied in the United States. And the interior cities and towns had benefited by the reflex of this competition, an interior town in Illinois, for instance, obtaining a rail freight rate on a par with Chicago under the rule of shorter and longer hauls. On the Canadian side this applied to towns like London and Brantford.

Henry I. Harriman, of Boston, said that there was a tendency today for water rates to go down while rail rates went up, and he believed that before long the old ratio of 5 miles by water being equal to 1 mile by rail would be reestablished.

The present charter rate for the movement of wheat from Duluth to Buffalo was 5 cents a bushel. Before the war it had frequently been as low as 2 cents. If the old prewar rates were restored a bushel of wheat could move through the canalized St. Lawrence from Duluth to Boston for less than 6 cents. What was true of wheat would be equally true of flour and even more true of package freight.

Julius H. Barnes discussed the rates on the transportation of grain by various routes to the Atlantic seaboard, and concluded that if the St. Lawrence waterway were opened so that either lake carrier would extend its trip down to Montreal or the ocean carrier go up to the head of the Lakes for its cargo, the transportation saving would be quite substantial, amounting, perhaps, to 10 cents a bushel. If this saving were fully reflected in the farm price it would mean a gain to the American farmers of $366,000,000 a year and to the western Canadian farmers of $44,000,000, or one-half these respective amounts if it were assumed that the farmer would only secure one-half the full measure of saving by the new route.

Hon. Herbert C. Hoover stated that it was a sound economic assumption that the price of all agricultural produce was made at the points in the world where that produce must meet the tide and flow of similar produce from other quarters of the earth. In other words, the price to the farmer would be increased by whatever saving might be made in transportation and handling up to the point where his price was fixed by the flow of world current. If by the construction of the proposed canal it was possible to secure navigation of ocean-going ships on the Lakes, or even of lake carriers to Montreal, in a period of two or three days, it was not difficult to calculate that the transportation of wheat from Buffalo to Montreal would not exceed, probably, 1 cent a bushel or, perhaps, 2 cents. Putting it at 2 cents at the outside, there was a saving of approximately 10 cents a bushel to the American farmer on his wheat reaching Liverpool.

At the Detroit hearing S. A. Thompson, secretary of the National Rivers and Harbors Congress, was quoted on the relative costs of different forms of transportation. Mr. Thompson's figures were based on the distances that $1 would carry a ton of freight by wagon, steam truck, rail, canal, and lake carrier.

The point he made was that the cost of transportation determined the distance from which raw materials could be drawn for manufacture and the distance to which the finished product could be shipped in competition with others in the same line of business. The nation, the city, the firm, or the individual that had the best, the cheapest, the most economical form of transportation available was the one that would win in the competition for trade anywhere on earth.

Capt. William H. Adams, of Detroit, estimated that a reasonable rate would be $10 a ton by water from Detroit to the Atlantic seaboard as against an average rail rate of $16 a ton, which would be equivalent to a saving on 3,000,000 tons of freight of $18,000,000 a year.

L. C. Burr, of Butler Bros., Minneapolis, who are large importers of china, glassware, etc., from Europe, thought that, allowing a substantial increase in ocean rates over prewar prices, a conservative estimate would show a saving of from 50 to 60 per cent in the carrying charges on this class of merchandise by the all-water route.

W. P. Trickett, of the Minneapolis Traffic Association, said that his judgment was that the ocean rate from the head of the Lakes on grain could be made not more than 10 cents per 100 pounds higher than obtained at the Atlantic seaboard, which would be equivalent to about 5 or 6 cents a bushel.

J. S. Brown, of the Chicago Board of Trade, stated that the best estimate that could be made at this time of the saving in transportation costs on grain from Chicago was to compare the present cost from Chicago to New York, all-rail as well as lake-and-rail, with the probable cost to-day by water, Chicago to Montreal, with ocean-going vessels. This comparison assumes the same ocean charge from Montreal and from New York to European ports. Based upon existing rates for cargoes of grain Chicago to Buffalo, he believed that a fair relative rate for water haul to Montreal, as a part of the through haul to Europe, would be 150 per cent of the Buffalo rate. Adding the insurance costs, the rate, Chicago to Montreal, would be

9 cents a bushel on wheat and correspondingly lower charges on corn, rye, barley, and oats. Compared with the rates, Chicago to New York via Buffalo, the saving in transportation by the Montreal route would be 9 cents a bushel on wheat, 8.32 cents on corn, 8.08 cents on rye, 7.09 cents on barley, 4.33 cents on oats. The annual saving in the cost of transporting 100,000,000 bushels of grain from Chicago by the St. Lawrence would be about $9,361,500 when compared with the all-rail route and about $8,126,000 when compared with the lake-and-rail.

Henry C. Barlow, of Chicago, discussing the relative earnings and cost of water transportation on the Lakes and by rail, showed that the average haul in 1912–13 by boat to and from Lake Superior was 831 miles, the average rate per ton 56 cents, and the average revenue per ton-mile .867 mill. Comparing this with the operations of the Lake Shore & Michigan Southern, the Pennsylvania, the Erie, the Delaware, Lackawanna & Western, the Lehigh Valley, and the New York Central Railroads, it was found that the average haul by rail was 147.19 miles, average earnings per ton 0.97224 cents, average revenue per ton-mile 6.6 mills. The average distance hauled by rail was 19 per cent of the water distance; earnings per ton were 173.35 per cent of the water earnings; a ratio of 8.97 to 1 in favor of water; i. e., 1 mile of rail was at that time equivalent to 8.97 miles of water.

As to the relative cost of rail against water transportation it appeared that the average cost per ton-mile of the rail carriers was 3.20 mills, or substantially half the earnings per mile. If this same ratio of expenses to earnings were applied to water service, it would be found that the cost of water-borne traffic to and from Lake Superior for 1912 was 0.335 mills per ton per mile, or substantially one-tenth of the cost by rail. It appeared therefore that the charges were 9 to 1 and the cost 10 to 1 in favor of water carriage. These figures were based upon the return of the carriers to the Interstate Commerce Commission and the 1913 report of the Chief of Engineers, United States Army.

In regard to the railways he saw no hopeful signs of a reduction in price of transportation. On the other hand, a serious diminution in the volume of traffic might at any time require a further advance in rates under the provisions of the transportation act. The result might very well be to discourage the production of food products. The future was fraught with sufficient seriousness to cause us to look the problem straight in the face and evolve plans that would really be effective.

Mr. Barnes cited a certain case before the Interstate Commerce Commission which had a bearing upon the relative cost of water against rail traffic. That commission had accepted the contention of the complainants that the proportion of water miles to rail miles was approximately 7 to 1.

In considering the cost of transportation between Great Lakes ports and Liverpool, as contrasted with the rates via the present rail and water route, MacElwee and Ritter attempted to separate the cost into its several elements, and in doing this they made use of a special report prepared for the United States Shipping Board, the results of which they tabulated. The study as applied to the present case was confined to three standard steel coal-burning vessels operated

between New York and Liverpool which would be suitable for use on the proposed deep waterway. Among the costs of operation were capital costs, depreciation, crew, subsistence, repairs and maintenance, insurance, fuel, pilotage and harbor charges. Tables were given showing the basis of costs and expenses and the distribution of costs. In instituting a comparison between transportation costs, Liverpool to Duluth and Liverpool to New York, it was assumed that the vessel which would carry the commerce of the Great Lakes to foreign markets were the vessels of average size now engaged in ocean service. Comparing the time and other factors on the two routes, the conclusion was reached that the vessel would have time to make four round trips between Liverpool and Duluth within the season of navigation still leaving time for two additional round trips from Liverpool to an Atlantic port, making altogether six round trips, as compared with seven between New York and Liverpool. The results of the comparison were shown in tabulated form. A similar comparison of cargo costs showed that grain, for instance, could be carried from Duluth to Liverpool for 16.4 cents per bushel, as against 12.5 cents from New York to Liverpool. To the latter must, of course, be added the cost of getting grain from Duluth to New York, which ranges between 15 and 20 cents, leaving a very substantial margin in favor of the Duluth-Liverpool route.

An even greater saving was shown on general cargo, the figures working out at $9.76 per ton on general cargo and from $2 to $4 per ton on grain. It was also pointed out that in the preceding comparison a stay in port at each end of 10½ days was allowed for both the Duluth-Liverpool route and the New York-Liverpool route. The writers felt, however, that it was an entirely reasonable assumption that having in view the difference in the terminal facilities and other conditions at Great Lakes ports and Atlantic ports the time in port for the former should be reduced to six days, which would place the Lake route practically on a footing with the New York route in point of time. A calculation was submitted in tabulated form of the cost of operating a 5,500 dead-weight ton package freighter, Chicago to Liverpool, above the cost per ton for which a shipowner could carry freight between Chicago and Liverpool and earn a moderate profit after paying all charges. The result of this particular study was to show that the additional cost of operating ocean vessels to Lake ports as compared with Atlantic ports was only a fraction of the saving which would result from the elimination of rail hauls and transfer charges.

At the various hearings in the eastern cities those who opposed the St. Lawrence improvement for the most part ignored the question of transportation rates as between the existing rail or rail-and-water route and the proposed all-water route.

W. L. Nixon, public service commissioner of the State of New York, instituted a comparison between transportation charges on the Great Lakes and the New York State Barge Canal, and argued that grain could not possibly be landed at Montreal from the West as cheaply as in New York. The present rates from Duluth to New York were between 9 and 10 cents, which was abnormally high. He thought rates would come down to 6 or 6½ cents a bushel.

Similarly, Adam E. Cornelius, of Buffalo, was convinced that as between the proposed route and the existing combination of lake carrier and canal boat to New York the latter would be the cheaper method of transportation. The present cost of carrying wheat by water via the Lakes and the barge canal and delivered on board steamers in New York Harbor would be about $4.50 a ton. He also was of opinion that the present lake rate was abnormal and was bound to come down again. Grain had often been carried from Duluth to Buffalo for 1 cent a bushel, and to-day it was 4 cents.

Evidence offered as to the relative advantages of refrigeration on boats and on cars was altogether favorable to the former. L. C. Hoopman, of the Equity Cooperative Packing Plant, Grand Forks, N. Dak., testified that between North Dakota and New York fresh meat shipped by rail during the summer had to have 12 icings. If any of these were neglected, the value of the product deteriorated. If the meat could be shipped via Duluth and the St. Lawrence, it would only need one icing on the car and would then be in a refrigerator on board ship which would guarantee absolute temperature, and the product could be delivered in New York or in the foreign markets in good condition.

Hon. Charles A. Dunning, of Regina, testified that in so far as the stock grower was concerned the development of a refrigerator service from the head of the Lakes to Europe would undoubtedly effect an economy in transportation.

R. S. Howe, president of the Skinner Packing Co., of Omaha, questioned as to the relative efficiency of steamer refrigeration and car refrigeration, said that the former was much more efficient. It cost money to ice cars. You had to keep up icing stations, carry the ice, stand the shrinkage during the summer months, and even then you did not get the efficiency that you get on the steamer.

C. B. Heineman, of the Institute of American Meat Packers, also testified that chemical refrigeration on steamers was much more satisfactory than icing on cars.

So far as foreign trade was concerned it was repeatedly asserted that the all-water route would have a decided advantage over the present rail-and-water route in time saving, and a similar advantage was also seen by several witnesses in the water route over the all-rail route for trade between the Great Lakes region and the Atlantic and Pacific seaboard.

PRODUCTION AND COMMERCE.

In answer to the assertion—it was hardly susceptible of argument from the negative point of view—that the region tributary to the Great Lakes did not produce or consume sufficient commodities to furnish cargoes outbound or inbound that would justify the expense involved in the deep waterway, an immense body of testimony was submitted at the various hearings as to the area, population, resources, production, banking and other facilities, and domestic and foreign commerce of the territory in question, designed to prove that this region was the most important in North America both as regards natural and manufactured products available for export and also as a consuming market for foreign goods.

Several witnesses who had made special studies of the subject attempted to define the area of the United States naturally tributary from a traffic point of view to the Great Lakes and the St. Lawrence waterway.

Hugh J. Hughes, of the Minnesota Department of Agriculture, described the boundaries of this area as the thirty-seventh parallel on the south, the crest of the Rockies on the west, the international boundary on the north, and the eastern limit of the Alleghenys on the east. In that area, which was practically one-third of the United States, 70 per cent of the food consumed was raised.

F. S. Keiser, of Duluth, described the same area as including all the territory of the States of Wisconsin, Illinois, Missouri, Iowa, Minnesota, North and South Dakota, Nebraska, Kansas, Oklahoma, Colorado, Wyoming, and portions of Indiana, Kentucky, Arkansas, Texas, New Mexico, Utah, Michigan, Idaho, and Montana. He was also of the opinion that much of the territory in more easterly States such as Ohio, New York, and Pennsylvania would be benefited by the establishment of the Great Lakes route. Mr. Keiser also described the area in Canada similarly tributary to the Great Lakes as the Provinces of Manitoba and Saskatchewan and portions of Ontario and Alberta.

J. A. Merrill, of the State Normal School of Wisconsin, outlined on a map the tributary territory in the United States which he estimated made a total area of 2,519,384 square miles.

H. C. Barlow, of Chicago, described the territory that under normal conditions, if the deep waterway were constructed, would find its outlet for export through Lake Michigan ports. A line embracing this territory would begin on the east of the Strait of Mackinac, proceed south midway between Lake Huron and Lake Michigan through Indiana to Louisville, and as far south as Nashville; then west, following the northern boundary of the State lines of Arkansas, Oklahoma, New Mexico, Utah, Colorado, and Arizona; then north to the southern boundary of the State of Idaho, and thence midway through the center of that State to the boundary of Montana; thence east through Montana to the northern boundary of South Dakota, thence to Winona, in southern Minnesota, and finally northeast to Green Bay, on Lake Michigan. The area of that territory was about 1,500 miles east and west and about 500 miles north and south.

MacElwee and Ritter in their brief went a step further in their treatment of areas. They submitted a series of maps, one showing the area tributary to the Great Lakes and the proposed waterway, for commerce with the United Kingdom and western Europe; another showing the area for commerce with Mediterranean ports; a third showing the area for commerce with South America; a fourth showing the area for commerce with the West Indies and Central America; and a fifth showing the area for coastwise commerce. Each of these tributary areas was discussed as a more or less distinct problem.

The question of the areas economically tributary to the proposed waterway as well as the population, resources, production, and trade of that area, will be discussed in the following part of the report. It may be of interest, however, to note here a table submitted by MacElwee and Ritter comparing the increase in value of manufac-

tures at five principal cities of the Great Lakes and on the Atlantic seaboard between 1899 and 1914, the percentage in the former being 118 and in the latter 79. This comparison was confined to the United States. While the figures of the 1919 census of manufactures of the United States were not then available it was stated that there was an increasing tendency to develop manufacturing industries in the region of the Great Lakes in close proximity to the raw materials of production and to the center of population. An interesting map was filed, prepared by Horace C. Gardner, giving the centers of production of the more important commodities entering into the export trade of the United States. It appears from this map that in most cases the center of production lies within the area economically tributary to the Great Lakes.

From a somewhat more restricted angle than the previous estimates as to production, Henry C. Barlow, in dealing with the territory tributary to Chicago, pointed out that the agricultural production, according to the 1920 figures, was valued at $7,863,148,000; the mineral production at $1,888,000,000; the industrial production, based on the figures of 1914, at $6,853,738,000. Taking the city of Chicago itself, Mr. Barlow showed that it had grown industrially from a total value of manufactured products in 1860 of $20,000,000 to an estimated total in 1920 of $6,500,000,000.

An important point bearing upon the ability of the country tributary to the Great Lakes to finance its foreign trade is its banking facilities. J. E. Ebersole, of the Federal reserve bank, ninth district, testified that the district extending from Sault Ste. Marie to the western boundary of Montana had in 1919 3,720 banks with an aggregate capital of $130,000,000, total resources of $1,978,000,000, and deposits of $1,688,000,000.

Willis W. Baird, of the Chicago Association of Commerce, stated that the banks of Chicago had total resources amounting to $2,299,222,000.

Dr. Walter Lichtenstein, representing the Chicago Clearing House Association, gave the capital and surplus of Chicago banks as $250,000,000; total deposits (September, 1920), $1,829,282,229; and cash reserves, $500,000,000. The large Chicago banks all had direct connections in every part of the world, and were not dependent upon New York or any other city for handling foreign business.

Henry C. Barlow testified that the bank clearings of the 27 principal cities in the area tributary to Lake Michigan amounted to $66,715,470,124 in 1919. Incidentally a fact might be mentioned here, brought out by Mr. Baird, as illustrating the financial strength of Chicago. He submitted a list of 39 firms picked at random from the list of 7,000 members of the Chicago Association of Commerce, and mentioned that each of these firms had a capital of at least $1,000,000, and the combined capital of the 39 members was something over $1,000,000,000.

Statements were made time and again by bankers at hearings in the different Western States as to the seriousness of the financial situation created by congestion on the railroads, congestion that was described more than once as closely approaching the collapse of the whole transportation system. It was pointed out that the banks were vitally interested in this situation because they had to finance

the crops, and when a large portion of the crops could not be moved they found themselves in the embarrassing position of having to finance two crops. Western bankers expressed themselves as strongly in favor of the opening of the St. Lawrence as a means of relieving the transportation deadlock, of cheapening the cost of transportation to the world's markets, of preventing the waste of produce due to transportation shortage, and of removing the stricture on the free flow of commodities from the producer to the consumer.

F. W. Cathrowe, of the Bank of North Dakota, emphasized the widespread influence of transportation congestion. Car shortage and inability to ship out grain had a very serious effect on the financing of industries and on business life generally. Every fall the banks had no end of trouble. Merchants were unable to collect their bills; bankers could not make collections; renewals had to be made, which meant higher rates; money was tied up. If there could be a quick shipment, and cars could be sent to the head of the Lakes to connect there with ocean ships, an immense saving would be effected not only in interest charges but in relieving capital for other purposes. The condition complained of had existed ever since he had been in the State and was getting worse. The banks were still carrying loans that ought to have been paid last fall (1919) and would have been paid had the cars been available. It all came back on the farmer who had to pay the interest.

Farmers also testified as to the difficulty they experienced in financing their crops owing to the transportation situation. The elevator companies were also heavily involved. J. W. Shorthill, of the Nebraska Farmers' Elevator Association, referred to elevator companies in that State whose interest charge, because of their elevators being permanently congested with grain, had mounted and mounted until in some cases it had become 400 to 500 per cent of what it would be under ordinary circumstances, and the same situation applied to insurance.

Charles F. MacDonald, of Duluth, thought he was absolutely correct in saying that the volume of money tied up in the handling and financing of the 1919 grain crop of the Northwest had been two or three times what it would be in a normal year. This situation reacted on the consumer, because the tying up of such a volume of grain resulted in higher prices for the quantity that was moving.

Several of the western bankers also testified as to the ability of the western banks to finance foreign trade. H. J. Karch, of the Fletcher American National Bank, Indianapolis, speaking from 13 years' experience in the foreign exchange business, 8 years of which had been with Wall Street banks, expressed the view that banks of the Middle West would have no difficulty in taking care of the export business.

Consideration may now be given to the prospects of development of foreign trade and also domestic trade with the seaboard. As to the latter, the opinion was repeatedly expressed that coastwise trade between the Great Lakes and Atlantic and Pacific coast ports would furnish a very important element of the commerce that would result from the opening of the St. Lawrence.

D. E. Woodridge, chairman of the iron ore committee of the American Institute of Mining and Metallurgical Engineers, stated that Atlantic coast consumers of iron ore were now looking to the Lake

Superior region for increasing percentages of their ore. In the spring of 1920, two and one-half million tons had been shipped from Lake Superior to Atlantic coast furnaces by lake and rail. This ore could advantageously be shipped by the all-water route, if the deep waterway were available. E. A. Hays, one of the mine owners of the Gogebic Iron Range, testified to the same effect.

Henry I. Harriman, of the Joint New England Commission on Foreign and Domestic Commerce, anticipated a very considerable trade between New England and the Great Lakes by way of the St. Lawrence in the shape of wood products, raw wools, hides, copper, etc., from the lake region, and textiles, shoes, machinery, etc., westbound from New England.

Clifton D. Jackson, representing the Springfield (Mass.) Chamber of Commerce made a comparison of distances and conditions between Great Lakes ports and New England points by rail and water, leading to the conclusion that the proposed waterway would offer economies of transportation equal to those offered to coastwise commerce by the opening of the Panama Canal.

Charles Whiting Baker, consulting engineer of New York, drew attention to the report of the United States Deep Waterways Commission of 1896, in which it was shown that the domestic traffic between the Middle West and the Atlantic seaboard was many times greater than the volume of trade with Europe, and that consequently ship transportation between lake ports and Atlantic coast ports was even more important than between lake ports and overseas ports. It would be cheaper because of the heavy terminal costs and transfer charges to take cargoes down the St. Lawrence and around to Atlantic ports than to break bulk at Buffalo and ship from there by rail or canal to destination.

R. S. MacElwee, in his evidence at the New York hearing, argued that the development of the St. Lawrence would lead to considerable trade by water between Great Lakes ports and Atlantic ports, and offered as an illustration of the economic practicability of such a route the successful trade between Liverpool and London and Mediterranean and Black Sea ports. Goods were carried by water between these points rather than by rail, although it involved three times the distance.

W. C. Cowling, traffic manager of the Ford Motor Co., described some experimental shipments his company had made by water from Atlantic ports to Pacific ports by way of the Panama Canal, which established the fact that this route involved a saving both in time and money over the all-rail route. The difference would be even greater if the St. Lawrence deep waterway were available. The Buhl Stamping Co., of Detroit, testified that there was a big demand along the Atlantic coast for their products which they were unable to supply because of very unsatisfactory transportation conditions. If they could ship direct by water, they could build up a good business. Similar statements were made by Clayton & Lambert, of Detroit, and other firms at the various hearings.

It was estimated that the business of Detroit with the Atlantic seaboard amounted to from five to six million tons annually, much of which could be profitably shipped by water at a very considerable saving in freight charges.

C. T. Bradford, traffic manager of the International Harvester Co., which has 22 plants scattered about the country, stated that his company was enthusiastically in favor of the St. Lawrence waterway. They believed that the waterway would probably afford better and cheaper transportation of their products from Chicago to coastwise points, particularly on the Pacific coast.

E. L. Cousins, chief engineer of the Toronto Harbor Commission, in discussing the possibility of bringing Pacific coast lumber around to Great Lakes ports, mentioned that in 1914 British Columbia fir had been brought around through the Panama Canal to New London by water and thence by rail to Toronto for $19 as against an all-rail rate of $34.25. Testimony was also offered as to the advantages of bringing Pacific-coast fruit to Great Lakes ports by way of the Panama Canal and the St. Lwrence.

The position of the opposition in the matter of foreign trade by way of the St. Lawrence has already been referred to. It was, in general terms, that there could not possibly be enough business to make the route economically practicable. It was argued that an overwhelming proportion of the present commerce of the Great Lakes consisted of bulk freight, principally iron ore, coal, and grain; that iron ore and coal did not enter into the problem at all, as they were entirely interlake traffic and would not be shipped to foreign markets even if a deep waterway were available; that grain could be carried more economically via the New York State Barge Canal than by way of the St. Lawrence; that the existing package freight formed only a negligible proportion of the total traffic of the Great Lakes; and that even if outbound freight were available in sufficient proportions to induce shipowners to send their vessels up into the Lakes there would be practically no return cargoes, and therefore the thing was quite impracticable. The same objections were offered as to the practicability of coastwise trade with the Lakes.

There does not happen to be any complete official record of the total commerce of the Great Lakes, but MacElwee and Ritter, by taking the commerce through the canals at Sault Ste. Marie, American and Canadian, and adding figures obtained from a statement of the commerce of the principal lake ports for 1916, prepared by the Corps of Engineers of the United States Army, arrived at the conclusion that the total commerce of the Lakes for that year was approximately 133,388,000 tons.

In reply to the argument outlined above, that the present freight handled on the Great Lakes would not find any markets by way of the St. Lawrence, MacElwee and Ritter quoted a report of the committee on canals of the State of New York to the effect that there was an enormous market for steel and iron in New York and New England, as well as abroad, and that this market could be supplied cheaply and advantageously by water. MacElwee and Ritter expressed the opinion that large quantities of Lake Superior iron ore would be carried by way of the St. Lawrence to furnaces along the Atlantic coast. On the other hand, they did not think that the present package freight of the Great Lakes was particularly interested in the proposed route, as this was largely local and interlake traffic not destined for the seaboard. The package-freight business which they anticipated would use the waterway to a very considerable

extent would be drawn from the vast movement between the Northwestern States and the seaboard that now went entirely by rail.

What MacElwee and Ritter said as to the markets for Lake Superior ore on the Atlantic seaboard was also confirmed by D. E. Woodbridge, of the American Institute of Mining and Metallurgical Engineers, who pointed out that consumers of ore on the Atlantic coast, who had formerly got their supplies from mines in Newfoundland, Cuba, Chile, and western Europe, as well as from New York and New Jersey, were now turning to Lake Superior. In the spring of 1920 2,000,000 tons have been sent to Bethlehem and the vicinity of Baltimore, and at least half a million tons to other Atlantic-coast furnaces. This ore went down the Lakes to Erie ports and thence by rail to the coast. One of the probable developments of the future was the establishment of a great steel industry in the vicinity of New York City, and this would probably be a very considerable consumer of Lake Superior ores, which could be taken around by the water route if that were available. There was also a strong probability that high-grade concentrates, to be produced from lean Lake Superior magnetic ores, would ultimately find a market in Europe if the all-water route were open, as these ores were especially adapted to the requirements of British steel makers, whose available reserves of low-phosphate ores in Spain and elsewhere were rapidly diminishing. Also, because of the mixtures of ores required to make certain types of pig iron and steel, it was not at all improbable that while Lake Superior ore might go out by water to the Atlantic seaboard and to Europe, the Newfoundland ore might use the same route inbound to points on the Great Lakes for mixing with Lake Superior ores.

In regard to coal, it was argued by Whitney Warner, of Cleveland, and other witnesses that European markets could be supplied with Ohio coal considerably more cheaply by rail to Erie ports and thence by an all-water route to Europe than by existing routes all-rail to the Atlantic seaboard and then by ocean vessels.

The question was also raised as to the practicability of bringing coal by way of the St. Lawrence from Cape Breton to supply the Ontario market. P. A. Hollinrake, of the Canadian Manufacturers' Assocation; A. E. Knobs, of London, Ontario; and H. A. Harrington, fuel controller for Ontario, expressed the view that if the deep waterway were available Nova Scotia coal could be landed in Toronto at least as cheaply as Pittsburgh coal. It may be noted, however, that very conflicting evidence was submitted to the two parliamentary committees, one of Canadian Senate and the other of the House of Commons, which in the session of 1921 investigated the question of Canada's fuel supply, and the practicability of bringing Nova Scotia coal up to Ontario by water, even with the help of the deep waterway, must still be regarded as an unsettled question.

In dealing with the volume of commerce that would be affected by the Great Lakes-St. Lawrence waterway MacElwee and Ritter emphasized the fact, already referred to in this report, that the territory tributary to the Great Lakes is both the most important producing section and the most important consuming section of the United States. They estimated the total foreign commerce interested in the proposed waterway as amounting, in round figures, to 40,000,000 tons, of which about 28,000,000 tons would be exports and

12,000,000 tons imports. This does not, of course, mean that all this tonnage is expected to use the St. Lawrence waterway.

The corresponding figures for the Canadian area are 7,500,000 tons exports and 1,000,000 tons imports, or a combined commerce for the international region of 48,500,000 tons. Similar estimates were prepared in connection with coastwise business interested in the deep waterway. The final conclusion was that the potential tonnage available for the waterway on both sides of the line, foreign and coastwise, was 24,000,000 tons.

A study of the testimony offered at the various hearings in connection with the probable exports and imports that would be available for the proposed deep waterway leads to the conclusion that the estimates offered by MacElwee and Ritter are conservative. The material on this subject embodied in the evidence is so voluminous that it would be hardly practicable to attempt to summarize it here. Among the exports for which substantial quantities were indicated were wheat and other grains, flour, dairy products, packing-house products, machinery and other steel products, automobiles, rubber goods, stoves, furniture, etc. The prospective imports included raw sugar, crude rubber, textiles, fiber, hides, lumber, tropical woods, pulpwood, groceries, tropical fruits, coffee, building materials, oils and pigments, glassware and china, fertilizer, etc.

It may be interesting to note as indicating the magnitude of the export business of the Great Lakes region that in the year 1919 the grain shipments of Chicago for export amounted to 285,000,000 bushels and the packing-house shipments, also for export, to 3,697,955 tons, valued at $1,160,623,643. A partial statement compiled from figures supplied by some of the principal Chicago firms showed a total value of imports, not including grain, of $1,190,360,000.

John A. Russell, of Detroit, estimated that the 27 sugar refineries in the States of Michigan, Ohio, Wisconsin, Minnesota, and Iowa would be in a position to import annually by way of the waterway about 472,500 tons of raw cane sugar. He also estimated that of the 285,000 tons of crude rubber imported into the United States fully 50 per cent were used in the tire-making industries of the Great Lakes and might reasonably be counted as prospective import tonnage by way of the St. Lawrence.

MacElwee and Ritter made a special study of the grain movement and its relation to an all-water route to the seaboard. They submitted tables, maps, and diagrams showing the average production of cereals for two periods, the net imports of wheat and rye for certain countries, the sources and principal markets of export wheat and rye, the production of grain in the United States, with separate tables for wheat, oats, barley, corn, and rye, and the geographic price variations of wheat in the United States. They showed that the annual exports of flour and grain from the United States during the last five years had averaged 424,000,000 bushels.

As to the argument that grain could not be a factor in the St. Lawrence problem because the domestic market was rapidly absorbing the American production, and that within a comparatively short time the United States would have no grain for export, it was stated time and again at the western hearings that the western grain country was very far from having reached its limit of production, that

there was an increasing tendency toward the adoption of more scientific methods, and that it only needed the stimulus of a fair profit to induce the farmers of the West to produce sufficient grain not only to supply the domestic requirement but also to look after a large percentage of the foreign demand.

Mr. Hoover emphasized this point when he said that something must be done to check the downward tendency of grain production, and that this necessary stimulus would, in his opinion, be afforded by the saving in transportation costs.

As to the practicability of lake freighters bringing grain or other cargoes down to Montreal by means of the deep waterway and transferring there to ocean steamers, witnesses at Buffalo and New York expressed a negative opinion.

Hugh Kennedy, of the Buffalo Chamber of Commerce, for instance, expressed the view that if the St. Lawrence waterway were available it would still be more profitable for lake carriers to unload at Buffalo than to go on down to Montreal. They could go back to Duluth for another cargo during the time it would take them to get to Montreal.

Adam E. Cornelius, of Buffalo, offered another argument in opposition to the idea of a Montreal transfer. His view was that there would be comparatively little return cargo for a lake boat from Montreal and that therefore that route would be seriously handicapped as compared with the Buffalo route because of the immense quantity of coal available for return cargoes from Lake Erie ports.

On the other hand, witnesses at several of the western hearings, such as C. C. West, of the Manitowoc Shipbuilding Co., saw a distinct advantage in grain being carried by lake carriers to Montreal and there transferred to deep-sea ships. His idea was that this system would be followed particularly just before the close of the season of navigation, when ocean going ships could not afford to take a chance of being frozen in. So far as package freight was concerned, it seemed to be the concensus of opinion that that could be more economically shipped through from lake ports to overseas ports than transshipped at Montreal.

All the Montreal interests, the board of trade and harbor commission and the shipping federation, were favorable to the idea of transferring western freight at Montreal. They took the view, in fact, that that was the only practicable water route for foreign trade, and that if the deep waterway were constructed at all on the upper St. Lawrence it should be only of sufficient depth to enable lake boats to get down to Montreal.

In reply to the argument that lack of return cargoes would make it unprofitable for lake freighters to go down to Montreal, James Richardson, of Kingston, stated that boats could be put on the service from Duluth or Fort William to Montreal with grain for from 8 to 10 cents a bushel and that at that figure they could afford to go back light. D. W. Stocking, of Duluth, testified to the same general effect.

In this connection it may be noted that Cornelius Elder, of New York, in comparing the time of an average cargo boat between Montreal and Liverpool, and between New York and Liverpool, said that it would be perhaps five or six days in favor of New York. On

the other hand, Magnus Swenson, of Milwaukee, stated that at the present time Scandinavian boats were using the port of Montreal to a very considerable extent, as they thereby saved a day's sailing as compared with the route to New York.

In the MacElwee-Ritter brief is found a table, prepared by the Hydrographic Office of the United States Navy, giving a comparison of sailing distances on the North Atlantic. From this statement it appears that the distance from Montreal to Liverpool is 2,785 miles and from New York to Liverpool 3,107 miles. The distance from Montreal to London is 3,126 miles and from New York to London 3,341 miles.

Testimony was offered on various occasions as to the capacity and equipment of shipbuilding plants on the Great Lakes, at Duluth, Toledo, Cleveland, Detroit, and elsewhere, and the belief was expressed by Mr. West, of Duluth, and others, that if the St. Lawrence waterway were open many of the shipbuilding plants on the Great Lakes would compete in building ships for this trade. The Manitowoc Shipbuilding Co. had already built a number of the smaller type of ocean-going vessels, 3,500 tons and under, and their facilities would be equally adaptable to the larger type of vessel.

A. M. McDougal, of the Duluth Shipbuilding Co., emphasized the extent of the production of ocean-going ships by shipyards on the American side of the Great Lakes in 1918. The capacity of lake plants had been doubled and trebled during the war and some 80,000 or 85,000 skilled workmen had been trained in the art of shipbuilding in American and Canadian lake yards.

Capt. William H. Adams, of Detroit, said that in view of their strategic position in relation to raw materials, the Great Lakes shipyards would be in a position to compete on very favorable terms with plants on the seaboard in the construction of ocean-going vessels.

MacElwee and Ritter raised the point that if the locks on the new waterway were of sufficient width and length, even the larger type of ocean-going ships could be profitably built on the Lakes and sent down light to tidewater.

Another point that was made by some of those that advocated the deep waterway was that it would help materially to solve the labor problem of the Middle West and the West by bringing in unskilled labor from Europe to the heart of the continent. All the basic industries of the West were being hampered because of the shortage of labor. The point was also made that immigrants would have a much better chance of developing into good citizens if they could be brought direct to the center of the country where they would find opportunities of making homes for themselves, rather than being absorbed by the big industrial centers on the Atlantic seaboard.

ALTERNATIVE ROUTES.

At different hearings a good deal of testimony was put in to prove that certain specified water or water-and-rail routes were or were not better adapted to the needs of commerce than the proposed St. Lawrence waterway. While the terms of the reference do not specifically call for any investigation of alternative routes, the commission's

report would hardly be complete without some reference to the subject, particularly as much of the opposition to the St. Lawrence waterway was based on the argument that it was not either the logical or the best available route. The water routes that at one place or another were put forward as preferable to the proposed St. Lawrence waterway were the New York State Barge Canal, the proposed Oswego Ship Canal, the Richelieu and Lake Champlain route, the Georgian Bay Canal, the St. Lawrence and Ottawa route, the Hudson Bay route, the Mississippi route, and the Pacific and Panama route.

A great deal of information in regard to the New York State Barge Canal was furnished the commission by witnesses at the hearings in Buffalo, Albany, and New York. The history and dimensions of this waterway have been given elsewhere in this report. It may be sufficient to say that the expenditure on the barge canal, which now has a nominal depth of 12 feet, has been approximately $175,000,000.

The State superintendent of public works, Edward S. Walsh, stated that terminal facilities were to be provided in connection with the barge canal at an expenditure of about $33,000,000. These would include grain elevators at New York, Oswego, Tonawanda, and Buffalo, as well as two piers at the Gowanus Bay Terminal of the canal in Brooklyn. Mr. Walsh expressed the view that with adequate facilities the barge canal could carry between 4,000,000 and 5,000,000 tons of freight in the season of navigation. The tonnage handled in 1919 on both the main canal and its branches amounted to 1,238,000 tons.

Various reasons were put forward by Frank M. Williams, New York State engineer, and others, to account for the apparent economic failure of the canal. The United States Government, it was said, had taken over the canal during the war, and their operation had not only been inefficient but had been designed to divert traffic to the railroads rather than to the canal. It was also to be remembered that during the 20 years the barge canal was under construction the older generation of boatmen had passed away, their boats were gone, and their business forgotten. It was necessary to educate a new generation to this type of water transportation and that was necessarily a slow process. Another witness said that the chief difficulty in making the barge canal a success had been the hostility of the railroads.

Senator Hill and other witnesses were of the opinion that when the canal had been finally removed from Federal control, and got its proper equipment of barges, etc., it would be quite capable of handling all the traffic that offered from the western seaboard.

On the other hand, many witnesses outside the State of New York expressed serious doubt as to whether the barge canal could ever be a serious factor in solving the problem of getting western commodities to the seaboard.

Julius H. Barnes said that because of its obvious limitations the canal could never expect to do anything more than supplement the tonnage movement of the railways. He filed a table showing the grain shipments and rate of carriage on the canal from 1900 to 1918. The limitations of the canal were also shown by the fact that the rail structure which would exist after March 1, 1921, would carry a rate alongside of the canal approximately 25 per cent higher than the grain rate for a typical haul, such as Omaha to Chicago, where there was no possible chance of water competition. Mr. Barnes could see no public service possible for the barge canal in national

transportation saving comparable in any way to the transportation economy promised by opening the Great Lakes to the sea.

W. C. Cowling, of the Ford Motor Co., and others, asked as to why they did not make use of the barge canal, stated that in addition to its limited draft and other disadvantages it necessarily involved a double transfer—from lake vessel to canal barge and again from canal barge to ocean vessel or tidewater storage—and these transfers were disastrous to many commodities.

Benjamin Stockman, of the Duluth-Superior Milling Co., described the experiences of his company with flour shipments by the barge canal in 1920. It has resulted in very serious delays and damage in handling. A comparison of rates, lake-and-rail and lake-and-canal, Duluth to New York, showed the export rate of the former to be 37½ cents a hundred and by the latter 34½ cents a hundred. Comparing the barrel charges, lake-and-rail cost for freight and insurance 76¾ cents and for lake-and-canal a little over 77 cents. They paid a higher rate for a poorer service via the canal.

Henry C. Barlow, discussing the limitations of the barge canal, pointed out that the railways had learned to compete successfully with barges carrying 200 or 300 tons of freight. They had not learned and never would learn to compete with a vessel carrying 5,000 tons of freight. That was the fundamental difference between the barge canal and the proposed St. Lawrence ship canal.

It was the definitely expressed opinion of MacElwee and Ritter that the barge canal would not provide the character of water transportation needed for the commerce of the West, and that it would not be used to any extent for through traffic of a general character to and from the ports of the Great Lakes. They and others, however, saw a great future before the barge canal in the development of industries along its route and the building up of an extensive local traffic.

Frank M. Williams expressed the view that if the people insisted on the construction of a ship canal the route to be followed should be the Oswego-Oneida-Mohawk route rather than the St. Lawrence. Other witnesses advocated the creation of a ship canal by way of the Oswego route in connection with the deepening of the Hudson.

Hon. George Clinton, of Buffalo, however, condemned this route, as well as the St. Lawrence, because it would involve many miles of restricted channel. Mr. Sargent, engineer of the New York Conservation Commission, referred to the survey made some years ago on behalf of the United States Government to ascertain the feasibility of connecting the Great Lakes with the Hudson by way of the Oswego route. This would entail more or less artificial waterways for 185 miles, at a cost at the present time, as figured by the State engineering department of New York, of about $500,000,000.

E. S. M. Lovelace, of Montreal, advocated a canal to connect the St. Lawrence at Montreal with the Richelieu at Chambly, and thence by way of Lake Champlain to the Hudson. Mr. Lovelace's scheme contemplated a canal of no greater depth than 14 feet. It may be noted that the United States Board of Engineers on Deep Waterways between the Great Lakes and the Atlantic tidewater in their report (1900) reported on both the Oswego-Mohawk route and the St. Lawrence-Champlain route for a ship canal.

At the hearings at North Bay, Ontario, as well as at Montreal, something was said as to the proposed Georgian Bay ship canal and its advantages as a water route from the Great Lakes to the sea. The Chambre de Commerce, of Montreal, advocate the Georgian Bay Canal in preference to the St. Lawrence route, because the former was a purely Canadian route and would be more beneficial to Canada.

E. L. Cousins, of the Toronto Harbor Commission, stated on the other hand that the Georgian Bay route had been investigated some years ago, and that it had been established that a vessel could be taken from Duluth or Fort William to Montreal by the St. Lawrence in much less time than by way of Georgian Bay. He also pointed out that the season of navigation on the latter route would be much shorter, and that it lay through an unsettled country. It may be noted that during the past 50 years or so a number of reports have been made to the Canadian Government on the practicability of the Georgian Bay ship canal, the most elaborate as well as the latest report upon the engineering features of the scheme being that of 1908, while in that and subsequent years Sanford Evans reported upon the economic practicability of the same route.

In this connection it may be noted that at the hearing in North Bay the board of trade and other interests strongly urged the desirability of improving the navigation of the French River as a feeder to the proposed Great Lakes-St. Lawrence route. It was stated that French River was a deep stream 60 miles long broken by three rapids. It would probably cost to-day about $20,000,000 to build canals around these three falls so as to give a depth of 21 feet from Georgian Bay to Lake Nipissing. The matter had been taken up with the Dominion Government and it was hoped that that Government would undertake the work.

At the Ottawa hearing, John Bingham and Noulan Cauchon, on behalf of the Ottawa Board of Trade, urged the advantage of an alternative waterway by means of a canal from Cardinal on the St. Lawrence to the city of Ottawa on the Ottawa River, and thence by the same River to the St. Lawrence at Montreal. It was estimated that this canal would cost about $50,000,000 and improvement of the Ottawa River between Ottawa and Montreal $30,000,000, making a total of $80,000,000. The canal would be 30 feet deep and 200 feet wide at the bottom. The proposed route would be about 45 miles longer than the St. Lawrence route. It was urged that in connection with this canal an extensive irrigation scheme could be developed which would add very largely to the value of the land in that part of Ontario.

At the hearings in Winnipeg and Regina, the commission heard a good deal about the advantages of the Hudson Bay route. It was urged that Hudson Bay was the natural outlet for the exports of western Canada; that this waterway has been used successfully for the last 250 years by the Hudson Bay Co., and that all that remained to be done to make the route available was for the Canadian Government to complete the railway to Port Nelson. The key to this route is Hudson Strait, and various estimates were offered as to the period during which the straits could be navigated, Charles F. Gray, of Winnipeg, even asserting that the route would be open all the year round. T. R. Deason, of Winnipeg, was much less optimistic as to the practicability of the route.

It appears from a statement of the Minister of Railways and Canals in the Canadian House of Commons that the Dominion Government has expended on the Hudson Bay Railway $14,284,552.62, and on the Port Nelson terminal of the same railway $6,305,891.71, making altogether $20,590,444.33. He estimated that under present conditions it would cost about $17,000,000 more to complete the work.

At the Winnipeg hearing some of the witnesses also advocated the opening of a water route from Winnipeg to Split Lake or Manitou Rapids on the Nelson River, about 200 miles from Hudson Bay, by way of Red River, Lake Winnipeg, and the Nelson River. The estimated cost would be $25,000,000 or $30,000,000. From Manitou Rapids to Hudson Bay would be covered by the railway.

The practicability of the Hudson Bay route has been investigated on a number of occasions at the instance of the Canadian Government. The consensus of opinion among those most familiar with conditions in Hudson Straits seems to be that the period of navigation, with the aid of all possible improvements to navigation, would be between two and four months. It has been pointed out by a competent authority that an even more vital point than the straits in the problem of navigation via the Hudson Bay route is the mouth of the Nelson River, which is frequently blocked by masses of ice driven down from the northern part of the bay.

For many years past the people of the Mississippi Valley have advocated the improvement of the Mississippi to enable at least the smaller type of ocean-going vessel to come up that river, and a number of official reports have been made on what is known as the Lakes-to-the-Gulf deep waterway, which provided for a route by way of the Chicago Drainage Canal and the Illinois & Michigan Canal to the Illinois River, and thence to the Mississippi and down to the Gulf. Senator Hill and others who opposed the St. Lawrence waterway urged that it would be preferable from an American point of view to spend money on the development of the Mississippi rather than on the improvement of the St. Lawrence. However, the Mississippi Valley Association, which represents the interests of all the States in that valley from Louisiana to Ohio and Montana, while strongly in favor of the improvement of the Mississippi, nevertheless adopted the following resolution at a meeting held in St. Louis April 21, 1920:

> We earnestly favor the prompt improvement by joint action of the United States and Canada of the St. Lawrence River so as to admit ocean-going vessels to the Great Lakes; also the development of the enormous hydroelectric power incident thereto. The improvement making, as it does, seaports of our lake ports would double the value of our internal waterways, and the whole would go far toward prompt and effective relief from the transportation deadlock under which the central heart of the country now suffers.

The attention of the commission was also drawn during the hearings to the possibility of a route, particularly for Alberta grain, to the European markets, by rail to Vancouver, thence by water via the Panama Canal. It appears that this route has been tested, and it is stated that the objection that grain would heat during the passage through tropical waters was not well founded when proper precautions were taken.

In addition to other arguments put forward at the hearings in Buffalo, New York, and other eastern cities against the proposed deep waterway, the financial condition of the two countries was advanced as an additional reason why the improvement should not be undertaken. Mr. McCarroll, of New York, expressed the viewpoint in this regard of opponents in the United States when he said that a period of reconstruction such as was now before the country, with the financial and other problems involved and with the already heavy burden to be borne by the people, it was undesirable to enter upon an enterprise of such magnitude and cost. Those who took a similar view on the Canadian side are fairly represented by the statement of Robert W. Reford on behalf of the Shipping Federation of Canada, in which he protested against the expenditure of millions of money on an unremunerative project by the people of Canada, who were already heavily taxed.

On the other hand, Senator Burton was not impressed with the argument that this was an inopportune time for the two countries to burden themselves with such a large expenditure. All the Governments were heavily in debt to-day, but this was no good reason for blocking a forward movement. Sometimes in preaching and practicing economy we make the mistake of refusing opportunities that would bring in a very substantial return. The preparations for the St. Lawrence work would occupy a considerable time, and before it would become necessary to provide funds the two countries would probably be in a more favorable position to finance the project.

The latter point was emphasized by Francis C. Shenehon, of Minneapolis. He could not see that the question of financing the project need be a matter of concern. It was too big a project to be carried through quickly, and was not so much a question of millions of dollars to be raised to-day as millions to be raised in a number of years hence. In his judgment as an engineer, no contract could in any event be let inside of five years. Even after Congress appropriated the money it would probably take two or three years for a thorough examination to be made by expert engineers. As he saw it, contracts could not be let before 1926 nor the work completed before 1930. By combining water-power development with navigation there would be no difficulty in so financing the project as to impose little or no burden upon the people of the two countries. On the other hand, Hugh L. Cooper, of New York, anticipated that the work could be commenced and completed in a somewhat shorter period.

It may be convenient in closing this part of the report to list in a general way the interests for and against the proposed St. Lawrence waterway, as represented officially at the hearings or by resolutions or other documents subsequently filed with the commission. Among the proponents of the St. Lawrence improvement were the States of Ohio, Illinois, Indiana, Wisconsin, Michigan, Iowa, Minnesota, North Dakota, South Dakota, Nebraska, Colorado, Montana, Wyoming, and Idaho, and the Provinces of Ontario and Saskatchewan. It may be noted that the governments of all these States were officially represented at the hearings either by the governor or other State official or through the Great Lakes-St. Lawrence Tidewater Association, of which each of them is a member. In the case of On-

tario, Sir Adam Beck at the Kingston hearing stated that he appeared not only for the Hydro-Electric Power Commission of Ontario but also on behalf of the Ontario Government, and at the Buffalo hearing the Government of that Province was represented by counsel. The Saskatchewan Government was represented by the provincial treasurer. While public hearings were held in the Provinces of Quebec, Manitoba, and Alberta, the governments of these Provinces were not represented and took no part in the discussions either for or against the project.

Among national and other organizations whose representatives appeared to support the waterway were the Canadian Deep Waterways and Power Association, Dominion Marine Association, Farmers' Elevator Association of Nebraska, Farmers' National Grain Association of Ohio, Farmers' National Grain Dealers' Association, Farmers' Union of Nebraska, General Federation of Women's Clubs, Great Lakes-St. Lawrence Tidewater Association, Hydro-Electric Power Commission of Ontario, Illinois Manufacturers' Association, Indiana Manufacturers' Association, Indiana Public Service Commission, Indiana Waterways Commission, Indiana State Chamber of Commerce, Institute of American Meat Packers, Michigan Federation of Women's Clubs, Minnesota Federation of Farm Bureaus, Minnesota Federation of Farmers' Clubs, Minnesota Livestock Breeders' Association, Minnesota Railroad and Warehouse Commission, Minnesota Waterways Commission, Mississippi Valley Association, Montana Livestock Commission, National Waterways Association of Canada, North Minnesota Development Association, South Dakota Development Association, South Dakota Grain Dealers' Association, State Federation of Farm Bureaus of South Dakota, Toronto Branch of the Canadian Manufacturers' Association, Wabash Valley Empire Association, Western Ontario United Boards of Trade, Wisconsin Railroad Commission, Wisconsin Waterways Commission.

As to local, commercial, and other organizations that supported the deep-waterway project, the following may be mentioned: Aberdeen Commercial Club, Adrian Chamber of Commerce, Akron Chamber of Commerce, Battle Creek Chamber of Commerce, Bay City Board of Commerce, Billings Commercial Club, Blind River Board of Trade, Border City Chamber of Commerce, Boise Chamber of Commerce, Bowmanville Chamber of Commerce, Brantford Chamber of Commerce, Brookville Board of Trade, Brookville Dairymen's Board of Trade, Bruce Mines Board of Trade, Casper Chamber of Commerce, Cass Lake Commercial Club, Chapleau Board of Trade, Chicago Association of Commerce, Chicago Board of Trade, Chicago Clearing House Association, Cleveland Chamber of Commerce, Collingwood Chamber of Commerce, Cornwall Board of Trade, Denver Civic and Commercial Association, DesMoines Chamber of Commerce, Detroit Board of Commerce, Detroit Transportation Association, Duluth Board of Trade, Dunnville Board of Trade, Eastern Ontario Municipal Power Union, Eveleth Commercial Club, Flint Chamber of Commerce, Fort William Board of Trade, Galt Board of Trade, Grand Ledge Board of Commerce, Grand Rapids Association of Commerce, Great Falls Commercial Club, Goderich Board of Trade, Hamilton Board of Trade, Hamilton Harbor Commission, Hibbing Commercial Club, Huron Commercial Club, Indianapolis

Chamber of Commerce, International Falls Commercial Club, Jackson Chamber of Commerce, Kakomo Chamber of Commerce, Kansas City Chamber of Commerce, Kingston Board of Trade, Ladysmith Chamber of Commerce, Langham Board of Trade, Lansing Chamber of Commerce, Lincoln Chamber of Commerce, Mankato Civic and Commerce Association, Michigan City Chamber of Commerce, Milwaukee Association of Commerce, Milwaukee Civic Association, Minneapolis Civic and Commerce Association, Mitchell Chamber of Commerce, Muskegon Chamber of Commerce, Oakville Board of Trade, Omaha Chamber of Commerce, Omaha Grain Exchange, Port Arthur Board of Trade, St. Catharines Chamber of Commerce, St. Cloud Commercial Club, St. Joseph Chamber of Commerce, St. Paul Traffic Association, Saginaw Board of Commerce, Sandusky Chamber of Commerce, Sarnia Chamber of Commerce, Sault Ste. Marie Board of Trade, Sault Ste. Marie Civic and Commerce Association, Scotts Bluff Chamber of Commerce, Sioux Falls Chamber of Commerce, South Bend Chamber of Commerce, Springfield Chamber of Commerce, Terre Haute Chamber of Commerce, Thessalon Board of Trade, Toledo Commerce Club, Toledo Produce Exchange, Toronto Board of Trade, Toronto Harbor Commission, Wassan Board of Commerce, Windsor Chamber of Commerce, Youngstown Chamber of Commerce. In practically every case the municipal organization of the cities or towns in which these commercial bodies were situated also supported the deep waterway.

On the other hand, a number of organized bodies definitely opposed the construction of a deep waterway via the St. Lawrence. The only State that officially opposed the project was New York, although a good deal of adverse sentiment evidently existed in other States on the Atlantic seaboard. Of national and other organizations that expressed themselves against the waterway were the Atlantic Deeper Waterways Association, Joint New England Commission of Foreign and Domestic Commerce, Hudson Valley Federated Chamber of Commerce, Maine Commission on Foreign and Domestic Commerce, New York State Chamber of Commerce, Rhode Island Commission on Foreign and Domestic Commerce, and Shipping Federation of Canada. Certain other organizations, such as the Associated Industries of Massachusetts, preferred to suspend judgment pending the receipt of fuller information.

The following local commercial bodies also opposed the project: Albany Chamber of Commerce, Boston Chamber of Commerce, Bronx Board of Trade, Brooklyn Chamber of Commerce, Buffalo Chamber of Commerce, Buffalo Corn Exchange, Buffalo Lumber Exchange, Buffalo Lake Grain Elevators, City Club of New York, Lynn Chamber of Commerce, Merchants Association of New York, Montreal Board of Trade, Montreal Chambre de Commerce, Montreal Harbor Commission, New Bedford Chamber of Commerce, New York Produce Exchange, Peekskill Chamber of Commerce, Philadelphia Board of Trade, Philadelphia Bourse, Philadelphia Commercial Exchange, Portland Chamber of Commerce, Providence Chamber of Commerce, Queensboro Chamber of Commerce, Troy Chamber of Commerce.

PART IV.

TRANSPORTATION PROBLEM.

In the preceding part of this report the commission has outlined ot only the substance of the testimony submitted at the various earings, but also that of the various briefs, memoranda, and other ocuments filed on behalf of different interests, sometimes favorable, ometimes unfavorable to the proposed improvement. Without reecting in any sense upon the character of other papers, the commision feels that the brief entitled "Economic Aspects of the Great akes-St. Lawrence Ship Channel," by R. S. MacElwee and A. H. itter, is so comprehensive as to demand fuller consideration. Notithstanding it is in a sense an ex parte statement, having been repared at the instance of the Great Lakes-St. Lawrence Tideater Association, it is in the opinion of the commission so imporant that the commission has decided to put it before the Governents in its entirety as one of the appendices to this report.

Before doing so, however, the commission has thought it well, lthough it has every confidence in the care and conscientiousness ith which Dr. MacElwee and Mr. Ritter prepared their material, o have the data embodied in their brief very carefully checked by competent statistician, who, after a painstaking analysis, has ound it to be, apart from some minor inaccuracies, thoroughly eliable.

At the same time the commission has thought it desirable to put efore the two Governments certain documents filed with the comission by Hon. Henry W. Hill, of Buffalo, and by the New York tate Commission in Opposition to the St. Lawrence Ship Canal, hich will be found in Appendix C.

Messrs. MacElwee and Ritter discuss their subject under the folowing principal headings: Relation of transportation to the economic fe of the Nation; the transportation shortage; the remedy for the efects in our transportation system; handicap of inadequate termial facilities; character of water transportation needed for the comerce of the Northwest; cost of transportation between upper lake orts and Liverpool; areas commercially tributary to the Great akes-St. Lawrence waterway; production of the tributary area; rief history of improvements for navigation on the Great Lakes; enefits from navigation improvements on the Great Lakes; comarison of navigation facilities on the Great Lakes with those of cean ports; character of navigation to be provided on the St. Lawence; comparison of the St. Lawrence with ocean routes; navigaion conditions on the St. Lawrence route; depths required for the ccommodation of vessels engaged in maritime trade; types and izes of vessels which carry the world's commerce; study of vessels

passing through the Panama Canal; will ocean vessels seek inland ports; the problem of return loads; commerce of the Great Lakes; volume of commerce affected by the Great Lakes-St. Lawrence waterway; the grain movement, other commodity movements; shipbuilding on the Great Lakes; water power; conclusions.

It may be noted in the first instance that these studies of Dr. MacElwee and Mr. Ritter are quite naturally written from the point of view of the United States, and in so far as they relate to the area economically tributary to the proposed waterway the data are confined to conditions on the American side of that area. It is regrettable that nothing comparable to this brief has been submitted to the commission dealing with conditions on the Canadian side of the tributary area. The commission has studied the reports of W. Sanford Evans on the economic features of the Georgian Bay Canal project submitted some years ago to the Dominion Government. These reports, although they relate to a different waterway project, have a bearing upon the economic features of the present undertaking, but as they are readily accessible it is not considered necessary to do more than refer to them here.

So far as the MacElwee-Ritter brief is concerned, it will be seen that it falls naturally into several broad divisions. First they survey the existing transportation situation, its defects, the vital need of an adequate remedy, and the nature of that remedy. Accepting the proposed water route by way of the St. Lawrence as the logical and natural remedy for railway congestion in the United States, they proceed to discuss the area that would be tributary to that route, its resources, production, and facilities. They then take up the route itself, the extent to which it has already been improved, and what is needed to transform it into a waterway for ocean-going ships from the head of the Lakes to the sea. Following this, they deal with the practicability and probability of ocean shipping using the waterway, discussing at considerable length and with the aid of authoritative statistics the volume of outbound and inbound commerce that might be expected to seek that route, both for foreign and coastwise trade. A short chapter is devoted to water power, but the treatment is merely incidental to the main problem of transportation and need not be further referred to here.

It would be convenient to set forth at this time the conclusions reached by Messrs. MacElwee and Ritter as the result of their studies of the economic aspects of the proposed waterway. They are as follows:

1. A channel 25 feet deep at low water in the St. Lawrence River between Montreal and Lake Ontario will enable the greater proportion of vessels engaged in foreign trade, and practically all vessels engaged in general coastwise trade, to enter the Great Lakes. The figures show that the ocean freight vessel of average tonnage has a loaded draft of about 21 feet.

2. At our principal ocean ports, scarcely 1 per cent of the vessels utilize the full available depth, while vessels on the Great Lakes customarily take advantage of every foot. A channel 25 feet deep at low water into the Great Lakes could be used by nearly all vessels now calling at the 30-foot harbors of the Atlantic, Gulf, and Pacific coasts.

3. The study of vessels passing through the Panama Canal discloses the fact that the vessels operating on this route between the important ports of the world have an average draft of 21 feet. The greater proportion of them could have delivered their cargoes to lake ports on a 25-foot channel, and nearly all of them on a 30-foot channel. Only 3.3 per cent of the vessels

passing through the Suez Canal since 1912 have had drafts as great as 27 feet. At New York, which is used by the largest vessels in the world, only 4.4 per cent drew 30 feet or more during the first six months of 1914.

4. A channel 30 feet deep will accommodate 99 per cent of the vessels customarily engaged in world trade.

5. Vessels of moderate size and draft are now in use on all the world trade routes and are the most suitable for use in developing the maritime trade of the Great Lakes. Most of them can be accommodated on a depth of 25 feet, and all of them on a depth of 30 feet.

6. Every increase of navigation facilities on the Great Lakes has brought benefits amounting to many times its cost, and if the opening of these waters to ocean vessels should lead to further expenditures for channels and terminal facilities, the outlay must be regarded as a high-grade investment which will return abundant dividends to the public.

7. The assumption that the restricted sections of the St. Lawrence routes will involve delays which will render the use of ocean vessels unprofitable is not supported by a study of the navigation conditions on this and other routes, nor by the practices with reference to vessel rates.

8. The rapid rise of the port of Montreal to a position second only to New York in the exportation of grain from the American continent is alone abundant proof that the navigation of the St. Lawrence under conditions similar to those now prevailing between Montreal and the Atlantic Ocean presents no difficulties of sufficient importance to prevent the full realization of the purposes for which the extension of this navigation is desired.

9. The European analogies show that the St. Lawrence waterway gives prospect of greater usefulness than many foreign deep-water routes which are in successful use at the present time.

10. It is a recognized rule of transportation that where there is a productive interior, ships will proceed as far inland as physically practicable, and there are many precedents to show that ocean vessels will enter the Great Lakes. Moreover, there will be a large amount of incoming and outgoing freight in full cargoes, for which vessels will be chartered or owned by the companies interested.

11. A wrong impression exists regarding return loads at our ocean ports. At a number of successful ports the exports are many times the imports. At Galveston the ratio is about 12 to 1; at Los Angeles, 20 to 1; at Portland, Oreg., 40 to 1; and at Newport News, 70 to 1. Moreover in some cases the imports do not proceed in any quantity from the countries to which the exports are destined. The consuming ability of the territory tributary to the Great Lakes, and the importance of the manufacturing industries which now import large quantities of raw materials from abroad, insure a greater proportion of return cargo than is obtainable at many of our successful ocean ports.

12. In the great interior section of the United States contiguous to the Great Lakes is centered a large share of the surplus agricultural and mineral production of the country, and the manufactured goods of this area go to every country in the world. It is essential to the future prosperity of the Nation that means be provided for placing these surplus products in foreign markets at low cost. The present rail haul of 1,000 to 1,500 miles, with the attendant cost and delay of transfer at Atlantic ports, is an unwarrantable handicap against our foreign trade, and seriously limits our ability to meet competition abroad. The opening of the Great Lakes to ocean vessels will remove the handicap.

13. The railroads of the country are inadequate to handle the traffic, whenever there is any traffic to handle. During the periods of business depression they do fairly well, but they are unable to carry the freight during the crop-moving periods and at times when commodities are in demand. The transportation shortage is responsible for the loss of billions of dollars annually. More cars mean more congestion. The real need is more routes, more outlets and better terminals. The Great Lakes-St. Lawrence waterway will have an important effect in relieving the transportation congestion, and will more than save its cost every year by eliminating losses due to inability of the railroads to move traffic.

14. The cost of getting freight through the terminals of the Atlantic coast frequently equals the cost of the rail haul from points as far west as Chicago. The extent to which these terminal charges burden the commerce of the United States is not generally appreciated. More and better terminal facilities must be provided, but of greater importance to commerce will be the opening of a

deep-water route to the heart of the country which will eliminate a large proportion of the transfers.

15. Estimates formerly made regarding the cost of barge navigation have not been sustained by actual experience. The traffic on the barge canal is not unlike that on other shallow waterways, and consists chiefly of low-priced products. Its capacity is not more than will be required for transporting the local traffic originating on its banks. Instead of avoiding a transfer it introduces an additional transfer, which renders it unsuitable as an outlet for the general commerce of the Great Lakes region.

16. Study of the cost of transportation by ocean vessels shows that the additional cost of running to upper lake ports as compared with Atlantic ports is only a fraction of the amount which will be saved by elimination of rail hauls and transfers.

17. Comparison of distances and costs of transportation from all parts of the world to the areas tributary to the Great Lakes, both by existing routes and by the Great Lakes-St. Lawrence waterway, shows that the latter route will effect important savings, amounting to as much as $10 a ton on some commodities. The territory tributary for commerce with the United Kingdom and western Europe has a population of about 41,000,000, and the area tributary for commerce with South America a population of about 30,000,000. The area tributary for coastwise traffic is smaller, but includes all of the important manufacturing districts adjacent to the Great Lakes, and this statement is also applicable to the area tributary for traffic with Central America and the West Indies.

18. The statistics show that the centers of production of many of the most important tonnage-producing commodities are within the territory tributary to the Great Lakes. In this territory are produced 75 per cent of the wheat, 65 per cent of the corn, 100 per cent of the flax, 85 per cent of the iron, 40 per cent of the copper, 74 per cent of the zinc, and 46 per cent of the lead. The important manufacturing industries of this territory include agricultural implements, automobiles and accessories, rubber manufactures, meat packing, iron and steel, paper, furniture, and many others.

19. The present commerce of the Great Lakes furnishes no basis for estimating the commerce of the Great Lakes-St. Lawrence waterway. The package freight, which has been referred to as being the only part interested in reaching tidewater, consists largely of local and interlake freight which is not interested in reaching the seaboard. Practically all of the grain and some iron ore, pig iron, and coal will use the deep waterway. The general freight interested in the waterway is the enormous tonnage which now moves entirely by rail between the Great Lakes region and the Atlantic seaboard. The total volume of this movement is now about 250,000,000 tons annually.

20. The savings on grain will amount to from 8 to 10 cents a bushel, and this saving will affect not only the grain which actually moves for export, but practically all that produced within the area tributary to the Great Lakes. This saving will amount annually to approximately the entire cost of the improvement required to admit ocean vessels into the lakes. In view of the importance of having available at all times a route which will enable the producers of the great Northwest to market their products expeditiously and economically at the moment of greatest demand, the opening of this deep-water route is regarded as of national importance and fully justified for this purpose alone.

21. The principal commodities which will be brought into the lakes over the deep waterway will be pulp wood, wood pulp, sulphur, china clay, coffee, cocoa, sugar, fruits and nuts, rubber, fertilizer materials, lumber, hides, canned goods, asphaltum, gums, tanning extracts, sago and tapioca, fibers and textile grasses, flaxseed, seed for planting, spices, vegetable oils, granite, and hardware. The principal commodities which will be shipped outward will be grain, iron ore, iron and steel, agricultural implements, automobiles and vehicles, salt, copper, meat and dairy products, and the countless manufactures of the industrial centers of the Great Lakes. Within a short period after completion of the deep waterway the commerce should amount to approximately 20,000,000 tons, with continued growth in the future.

22. The Great Lakes are regarded as a most advantageous location for shipbuilding, due to the availability of an abundance of iron ore and other essentials of steel manufacture. The proposed enlargement of the channels affording access to the Great Lakes will permit the shipyards on the lakes to

construct vessels of all sizes and types, except the very few express liners, and will be of great value to this industry.

23. The water-power development will not only afford a revenue which will maintain the improvement and amortize the full cost within a reasonable period, but it will be the direct means of creating a vast industrial development which in itself will provide a large traffic on the waterway consisting of the raw materials so abundantly provided by nature in the region of the Great Lakes, and of the finished products which will be transported direct by ocean vessels to foreign and domestic markets.

These conclusions are submitted here as a matter of information, and are not necessarily the conclusions of the commission, which will be found in Part VI of this report. The commission's principal interest is in the data upon which Messrs. MacElwee and Ritter base their conclusions, and these data are so important that it has seemed desirable to bring them, as far as possible, down to date and supplement them with additional data wherever that appeared necessary.

The commission wishes to emphasize the fact that the object of this as well as the preceding part of the report is not to reach conclusions, but merely to bring together for the information of the Governments the evidence upon which its conclusions are based. It may also be pointed out, in explanation of the fact that in this part some features of the transportation problem are dealt with at considerable length while others are not discussed at all, that the former represent independent statistical studies submitted in amplification of those of Messrs. MacElwee and Ritter, and that, so far as points not discussed here or in the preceding part are concerned, the commission has nothing material to add to the data of Messrs. MacElwee and Ritter, which are accepted as reliable and as adequately covering the points in question.

It might perhaps be argued that some of the material brought together in the following pages, as well as in the MacElwee and Ritter brief, has only a comparatively remote bearing upon the problems entrusted to the commission, but, on the other hand, it must not be forgotten that that problem is extremely intricate and far-reaching. In any event, the commission has thought it better to err on the side of inclusiveness than perhaps to overlook a point that might ultimately prove important. To get a complete view of the economic aspects of the transportation problem in the United States, so far as the present investigation is concerned, the pages that follow should be studied in connection with Part III and with the MacElwee-Ritter brief and other economic material in the appendix.

For the Canadian side of the problem, the commission has brought together and embodied in this report such information as to the resources, production, and foreign trade of the four Canadian Provinces embraced in the tributary area—that is, Ontario, Manitoba, Saskatchewan, and Alberta, as are necessary to complete the presentation of this phase of the St. Lawrence investigation. In considering this material it is important to bear in mind the essential difference beween the United States and Canadian sides of the tributary area, particularly as to population and production. Canada compares favorably enough with the United States in territory and resources. That is to say, if the area economically tributary to the proposed waterway on the United States side of the boundary were duplicated on the Canadian side of the boundary, the undeveloped

natural resources of the Canadian area would compare not unfavorably with the undeveloped natural resources of the United States area. But when one comes to consider those resources in terms of production and trade the situation is found to be radically different. In population, wealth, in every branch of production, in transportation, financial, and other facilities, and in actual volume of foreign trade, the disproportion between the United States and Canadian sides of the tributary area is so marked that it constitutes a very serious factor in the problem and one that must be constantly borne in mind.

In discussing the economic features of the transportation problem, so far as they have a bearing upon the present investigation, the commission has adopted a somewhat different plan from that of the MacElwee-Ritter brief. In the following pages it takes up first the extent and character of the tributary area its population, resources, and production. Then it discusses the existing transportation facilities serving that area, including terminals, and the effect of opening the proposed deep-water route to the Atlantic seaboard.

In connection with the data submitted in this report as to the trade of the area economicaly tributary to the proposed waterway with overseas countries as well as with points on the Atlantic and Pacific seaboards, it will, of course, be borne in mind that the enormous totals of existing exports and imports of the tributary area are not for a moment expected to be diverted in their entirety to the proposed waterway. The anticipation is merely that certain commodities embraced in that commerce, with the probable addition of entirely new trade created as a result of the opening of the waterway, will seek that thoroughfare as the most economical route between the interior of the continent and the sea.

TRIBUTARY AREA IN UNITED STATES.

It has already been noted in the preceding part of this report that Messrs. MacElwee and Ritter submitted in their brief a series of maps showing the area on the United States side economically tributary to the proposed waterway for commerce, first, with Great Britain and western Europe; second, with Mediterranean ports; third, with South America; fourth, with the West Indies and Central America; and fifth, for coastwise commerce. It will be sufficient to discuss the first and most important of these areas, the same considerations applying very generally to those that follow.

In the brief the area tributary for commerce with Great Britain and western Europe is determined first upon the basis of distance and afterwards upon the basis of present rates and costs. The former is perhaps the more permanent basis, as costs are fairly proportional to distances; and rates, especially ocean rates, are more dependent upon commercial and other considerations, which might be appreciably changed after the proposed waterway was in successful operation.

Owing to the fact that Liverpool is some 900 miles farther north than New York, and to the course of the St. Lawrence River directly toward Liverpool, Buffalo is just about the same distance from Liverpool as New York. Therefore, on the basis of no other consideration

than distance, the proposed waterway would have the advantage over rail-and-water transportation via New York for all lake ports. Of course, the greater cost of rail transportation over water-borne commerce and the excessive terminal and transshipment costs, due to present inadequate rail-and-water terminal facilities at Atlantic ports would greatly increase this advantage.

For inland points which might ship by rail either to a lake port or to an Atlantic port, thence by water to Liverpool or other western European ports, a comparison of the simple sum of the rail-and-water distances is sufficient to include as tributary the area shown on the map, without recourse to the known facts that water-borne commerce is cheaper than rail and that the routes via Atlantic ports are made up of a relatively greater proportion of rail mileage than those via lake ports.

It is estimated that 1 ton-mile via rail costs as much as 6 ton-miles via water, and if this were taken into consideration the area tributary via lake ports would extend beyond the shaded area on the map. For Colorado and other Western States, where the proportion of rail mileage is greater via lake ports than via Pacific ports, this difference in cost is taken into consideration.

In determining the extent of the tributary area on the basis of rates, it has been estimated that New York would have an advantage over Lake Erie ports of $1.50 to $2 per ton, and over Duluth and Chicago of $2 and $2.50 per ton as far as the actual cost of the water haul is concerned.

Inasmuch as the rates for the United Kingdom are the same for all North Atlantic ports, although the distance to Baltimore is 535 miles longer than to Boston, and as the rates to Gulf ports are only 15 per cent higher than those to North Atlantic ports, although the distance is 40 per cent greater—15 per cent increase in rate for 1,600 miles increase in distance—it would not be surprising to find that the lake ports would get the same rates as North Atlantic ports.

At any rate, the present rates from Gulf ports are $3 per ton higher than from North Atlantic ports, which is as great or greater than the above-mentioned differences in cost of the water haul as between New York and lake ports, so that it is reasonable to assume that rates from lake ports would not exceed those from Gulf ports.

Using the rates from Gulf ports to Europe as applicable from lake ports and combining them with rail rates from inland points, a comparison with rates similarly combined via North Atlantic and Gulf ports indicates that traffic in the tributary area should go cheaper via lake ports than by either Atlantic or Gulf ports.

It is noteworthy that the present rates on coal from the New River, Kanawha, and Big Sandy districts of West Virginia are cheaper to lake ports than to Newport News, Va. Therefore it might be said that West Virginia's entire coal production would be tributary to the Lakes route, or at least would derive the benefits arising from being in competitive territory.

The demarcation of the tributary area on the charts is conservative in that it extends over no more area than that over which the figures used clearly indicate cheaper transportation rates and costs on traffic shipped by the lake ports. Assuming the figures cited would not be unfavorably changed by adjustments of rates after the

proposed waterway was constructed and in service, a considerable zone of competitive territory outside the demarked area would exist which would apparently be benefited by the opening of the proposed waterway.[1]

TRIBUTARY AREA IN CANADA.

The area in Canada economically tributary to the proposed deep waterway embraces the four Provinces of Ontario, Manitoba, Saskatchewan, and Alberta, or such portions of those Provinces as contain a sufficient population to insure a material contribution to production and foreign trade. Because of its relatively sparse population this Canadian area will be found much more restricted than that on the United States side of the boundary. As a matter of fact, if the lines bounding the United States area were projected into Canada to embrace a corresponding territory, they would extend far into the unoccupied regions of northern Canada. The tributary area in Canada may be roughly described as including the southern halves of Alberta, Saskatchewan, and Manitoba, with that portion of Ontario lying south of the Canadian National transcontinental railway.

Except in so far as the products of Alberta find to-day, or may find in the future, an outlet by way of the Pacific, and the products of the three prairie Provinces may some day reach Europe by way of the Hudson Bay route, there can be no doubt as to the fact that the Canadian area outlined above would be economically tributary to the St. Lawrence route.

POPULATION.

In Appendix B2 will be found a table showing the population by States in the tributary area in the United States for four decades ending with 1920, in which year the proportion of the total population of the United States found in the tributary area was 39.7 per cent. Population densities are also shown in the table. It appears from this table that the total population of the tributary area of the United States in 1920 was 41,985,140. The population of the Canadian area is as follows, according to the Dominion census of 1921:

Ontario[2]	2,900,000
Manitoba	613,008
Saskatchewan[2]	750,000
Alberta	581,995
Total	4,845,003

It will be seen, therefore, that the population of the area on both sides of the boundary is now about 46,830,143.

PRODUCTION OF TRIBUTARY AREA IN UNITED STATES.

Tables that have been prepared for the commission show by industries the proportion of the total value of products produced in 1914 within the area tributary to the proposed waterway and the

[1] See Appendix B for comparative tables of rail rates and rail-and-water rates via various ports.
[2] Estimated.

per cent increase since 1914.[1] Twenty-eight important industries are listed, in most of which, especially the largest ones, the proportion falling within the tributary area is well over 50 per cent. Among the more significant may be mentioned the following:

Industry.	Value of products produced in the tributary area in 1914.	Proportion of the total for the United States produced in the tributary area.	Increase, 1919 over 1914.
		Per cent.	*Per cent.*
Slaughtering and meat packing	$1,139,484,000	69.0	143.4
Automobile manufacture	450,992,000	89.7	374.5
Flour and grist mill products	511,545,000	58.3	149.9
Iron and steel works and rolling mills	788,095,000	85.8	206.2
Clothing, men's	150,234,000	34.3	152.7
Printing and publishing, newspapers and periodicals	170,041,000	34.2	80.0

The importance of manufacture in the North Central States is due to the proximity of basic raw materials, the intelligent character of the population, splendid agricultural resources, and other factors. High-grade coal for power purposes and metallurgical uses is mined in Pennsylvania, West Virginia, Ohio, Indiana, Illinois, Iowa, and Kansas, thus practically bisecting the region. The Lake Superior region affords the best supply of iron ore in the world, while the great wheat belt furnishes grain for the flour mills of Minneapolis, and the corn belt fattens the animals for the great packing houses of Chicago and Kansas City.

The accompanying table[1] shows that 63.3 per cent of the aggregate value of all farm property in the United States is within the tributary area of the proposed waterway and that the rate of increase of value of all farm property within the tributary area has been greater than that outside the area. The information is from the reports of the census and the compilation is a conservative estimate of the values in the tributary area. These results are significant because of the very great importance that agricultural production plays in the exports of the United States.

Reference to a paper on "Arable land in the United States," published in 1918 Yearbook of the United States Department of Agriculture, shows graphically by its accompanying maps that the best farming land in the United States is that in the upper Mississippi, Ohio, and Missouri River Valleys. The accompanying tables indicate the same thing. Of the 2,973.890 square miles of land surface in the United States, 1,232,645, or 41.5 per cent, lies in the tributary area of the proposed waterway. The value of all farm property in this area is $49,319,331,000, as against $77,925,989,000 for the total United States, or 63.3 per cent. This gives an average of $40,010 per square mile for that in the tributary area as against $26,203 for the United States.

The value of all farm property includes the improvements, as well as the land itself, and the table shows that the area tributary to the proposed waterway is more highly developed and organized for agri-

[1]Appendix B8.

cultural production than any other part of the United States. This relatively greater development of farming property in the tributary area is due to the general fertility of the soil, to the open, flat character of the topography, and to the adequate rainfall.

The portion of the United States which is tributary to the proposed Great Lakes-St. Lawrence waterway is one of the most remarkable agricultural regions in the world. It is naturally favored by smooth topography, fertile soil, adequate rainfall, and other factors.

The tables in Appendix B shows the production of agriculture in 1919 and 1909 for the several States in the area as reported by the United States Census. In many instances a decrease in quantity is accompanied by an increase in value, due to the inflation of the currency during the war. In the tables both quantities and values are given, thus avoiding misleading comparisons.

Iowa leads in corn production, and in this respect is closely followed by Illinois, Nebraska, Indiana, Ohio, and Missouri. These States also lead in the business of fattening animals for slaughter in the packing houses in Chicago, Kansas City, Omaha, and other cities, the leading States in raising hogs being in almost the identical order as above for corn. In the case of beef cattle, Ohio, Indiana, and Illinois are replaced by Kansas, South Dakota, and Colorado, which are nearer the grazing ranges.

The large wheat-producing States are Kansas, Illinois, Missouri, North Dakota, Ohio, and Indiana. Oats are grown by the same States that grow corn and for the same purpose, with the exception of Wisconsin and Minnesota, where it is grown for the benefit of dairy cattle. Wisconsin, Minnesota, and Iowa lead in the production of hay and forage, and Minnesota, Wisconsin, and Michigan in production of potatoes. Michigan, Missouri, Ohio, and Illinois are leading producers of fruits and nuts. The leading States in the region in truck farming are Ohio, Michigan, and Illinois. Wisconsin leads by far all other States in the tributary area in dairying, Ohio, Minnesota, Illinois, and Michigan following. Iowa, Missouri, Illinois, and Ohio are the leading poultry-raising States. The wool-producing States are Wyoming, Montana, Idaho, and Ohio.

In 1919 the area tributary to the proposed waterway produced an aggregate of 3,344,151,093 bushels of cereals of all sorts, valued at $4,718,042,984. The value of other seeds and grains produced in the tributary area was $131,863,094, making an aggregate value of all cereals, seeds, and grains produced in the tributary area of $4,849,906,078. The figures are from the 1919 United States Census reports. Figures for the whole United States are not yet available.

Another table in Appendix B shows by States the quantities of butter, butter fat, chickens raised, eggs produced, and wool produced in the tributary area in comparison with the total United States.

Wisconsin, Minnesota, Michigan, and Iowa are the leading dairying States in the tributary area, the total production of which totals 68.3 per cent of the total butter and butter fat production of the United States.

Iowa, Illinois, Missouri, Ohio, Indiana, and Kansas are the leading poultry States in the area, the total production of which was 51.2 per cent of the chickens and 57.3 per cent of the eggs produced in the United States.

The leading wool-producing States in the area are Wyoming, Montana, Idaho, Ohio, and Colorado, the area producing 57 per cent of the total wool production of the United States. The figures are from the United States census, 1919.

The number of domestic animals on farms in the tributary area is also shown in Appendix B1. The figures do not include the animals in village barns, in city stables, in stockyards, and elsewhere not on farms, the aggregate of which is less than 3 per cent of the total of domestic animals in the country.

The leading States in the area in horses and mules are Iowa, Missouri, Illinois, Kansas, and Nebraska. Missouri leads in mules and goats. The leading cattle States are Iowa, Nebraska, Wisconsin, Minnesota, Illinois, and Missouri. In the corn and oats growing States of Iowa, Nebraska, Missouri, and Kansas beef cattle predominate, and in Wisconsin, Minnesota, Ohio, and Michigan dairy cattle predominate. The leading hog States are much the same as the beef cattle States, Iowa, Illinois, Missouri, Indiana, and Nebraska leading. The leading sheep and goat States are Idaho, Ohio, Montana, Wyoming, and Colorado.

More than half the domestic animals in the country are to be found in the tributary area, the percentage for each kind being given in the table. The figures are from the United States census, 1920.

The annual product of the United States portion of the fisheries[1] of the Great Lakes is about 100,000,000 pounds of fish of various kinds valued at $6,500,000. The capital investment involved is about $10,500,000. The figures are taken from the United States Bureau of Fisheries Document No. 892 and are for the year 1917. Owing to the limited appropriations available for this work, the estimates for the Great Lakes are taken only at irregular intervals, the latest one being in 1917 and the one previous to that in 1908. The accompanying table gives the detail figures by Lakes for the year 1917.

The Mississippi River division produced in 1908, the latest year for which figures are available, 148,284,000 pounds of fish, valued at $3,125,000. The capital invested was $1,440,000. Assuming that half of this falls within the tributary area, the total figures for the tributary area in the United States are: Capital invested, $11,452,879; quantity of fish produced, 180,578,392 pounds; valued at $7,976,027.

The capital invested in mines and quarries in the area tributary to the proposed Great Lakes-St. Lawrence Ship Canal was, in 1912, $3,393,200,000 and the value of the products $1,747,765. The capital investment was 48.8 per cent, and the value of the products 55.3 per cent of that for the whole United States.[1]

The figures are from the reports of the census, except those for Pennsylvania and West Virginia for 1919, which are not yet available. The figures given are from the United States Geological Survey, comparability of which with the census figures is defective.

Bituminous coal, natural gas, and petroleum only have been used for Pennsylvania and West Virginia, the great mass of the production of these minerals falling in the tributary area. The portion not falling in the area is more than offset by other minerals not

[1] See Appendix B1.

included and by the production of a portion of Kentucky in coal, gas, and petroleum, which is properly within the tributary area, but has not been included, and by the mineral production of the tributary portion of New York which has not been included in the figures in the table.

In 1919 the capital invested in mines and quarries in the tributary area was nearly $3,393,218,000 and that for the total United States $6,955,468,831, the proportion of that for the tributary area to the whole United States being 48.8 per cent.

The total production of bituminous coal in the United States averaged 529,664,413 tons per year for the five-year period 1916 to 1920. Of this gross amount 442,396,755 tons, or 83.5 per cent of the total, represented the production of the tributary area. When the years are considered separately it appears that while the bituminous coal production of the United States has varied considerably from year to year the percentage produced within the tributary area has remained almost constant, ranging from 82.7 per cent in 1919 to 83.8 per cent in 1920.[1]

In making these computations, as given in detail in the accompanying table, the States of Pennsylvania and West Virginia have been included within the tributary area, as the great bulk of the bituminous coal deposits therein are within that area. On the other hand, in order to be entirely conservative, the State of Kentucky has been excluded in computing the production of the tributary area, although a considerable part of the Kentucky coal fields would logically find the Great Lakes to be their easiest and cheapest outlet.

The figures here cited are taken from the annual reports of the Geological Survey on "Mineral Resources of the United States."

The largest iron-ore producing States are Michigan and Minnesota, both of which are within the tributary area. Together these two States produce over 80 per cent of the total iron-ore output of the United States. For the five-year period 1916 to 1920 the total iron-ore production has been 70,268,392 long tons per year, of which 60,186,441 tons, or 85.7 per cent, has come from the tributary area, without including any of the production of New York or Pennsylvania, both of which States are important producers of this commodity.[1]

The figures here used are derived entirely from the annual reports of the Geological Survey on "Mineral Resources of the United States." In certain instances "shipments from the mines" have been used as synonymous with production, as the two sets of figures differ but slightly and in some cases the reports do not clearly distinguish between shipments and production.

Very nearly three-fourths of the total by-product coke production of the United States is concentrated in the territory commercially tributary to the proposed waterway. Detail figures of the production by States are given in the table,[1] which shows that Alabama is the only State with any considerable production which lies outside the tributary area.

The coke from these ovens is used in metallurgical reductions and the by-products, consisting of illuminating and fuel gas, coal tar, ammonia, etc., are used as raw materials for the manufacture of

[1] See Appendix B1.

roofing paints and compositions, binder tar for macadam highways, and a great variety of chemical products.

The total production of copper in the United States during the past five years has ranged from 1,927,000,000 pounds in 1916 to 1,200,000,000 pounds in 1920. The average for the period has been 1,643,000,000 pounds. States within the tributary area, as shown in the attached table, have furnished from 28 to 33.2 per cent of the total copper output, the percentage for the five-year period being 30.1. The important copper-producing States within the tributary area are Michigan and Montana. Pennsylvania, which produces a small amount of copper, is not here included as part of the tributary area.

The figures cited are taken from the annual reports of the Geological Survey on the "Mineral Resources of the United States."

The figures for cement "shipped" are cited below in preference to the actual production figures, as the former are more complete and differ but slightly from the actual production, as practically all cement manufactured later enters into "shipments."[1]

The total amount of cement shipped averaged for the 5-year period 1916 to 1920, 87,791,063 barrels per year, of which 38,080,671 barrels, or 43.4 per cent, was produced within the tributary area. The total value of the yearly shipments for the same period averaged $138,180,107, of which $58,685,483, or 43.1 per cent, applied to the shipments originating within the tributary area.

The above figures for the tributary area do not include New York, which has an average production of some 5,000,000 barrels, or the eastern part of Pennsylvania, which has a very high output of cement. In order to apportion the production of Pennsylvania, an analysis has been made of the cement-producing plants, with the result of showing that approximately 78.5 per cent of the total production has the seaboard as its easiest outlet, while the remaining 21.5 per cent is in the western part of the State and tributary to the Great Lakes region. The figure of 21.5 per cent has therefore been applied to the total production of Pennsylvania in order to obtain the amount and value—6,180,937 barrels and $6,000,789, as shown by the table—to be included in the tributary area for the purposes of computation.

All data cited are from the annual reports of the Geological Survey on "Mineral Resources of the United States."

The total volume of standing timber in the United States amounts to approximately 2,736,000,000,000 board feet, of which 2,214,000,000,000 represents saw timber and 521,666,000,000 represents cordwood. The standing timber in the Lake and Rocky Mountain regions, which fall within the area tributary to the Great Lakes, amounts to 15.1 per cent of the total standing timber and also 15.1 per cent of both the total saw timber and cordwood, the figures for the tributary areas being 412,243,000,000 board feet both saw and cord, 333,251,000,000 feet saw timber alone, and 73,992,000,000 feet cordwood alone.[1]

The amount of standing timber is not reported by States, but only by large regions. Roughly, the so-called Lake and Rocky Mountain regions fall within the tributary area. The southern end of the

[1] See Appendix B1.

Rocky Mountain region extends almost to the Mexican line, but the relatively small amount of standing timber thus included in the tributary region is probably more than compensated for by that part of the timber in West Virginia, Pennsylvania, and New York, which would find the Great Lakes and the St. Lawrence their cheapest outlet.

Satisfactory information regarding timber resources is limited to that contained in the special report of the United States Forest Service entitled "Timber depletion, lumber prices, lumber exports, and concentration of timber ownership," June 1, 1920. All the data here cited are based on that report.

During the five years, 1916 to 1920, inclusive, the total lumber production of the United States averaged 175,849,860,000 feet per year. Of this total, 30,733,387,000 feet, or 17.4 per cent of the total national production, came from the States constituting the tributary area. In 1916 the lumber production of the United States was greater than it has been during any subsequent year, and in 1916 the lumber production of the tributary area States represented 18.2 per cent of the production of the whole country.[1]

Authority for these statements and for the detailed data presented for each State in the table, which shows production of lumber, shingles, and laths, is found in a publication of the Forest Service of the United States Department of Agriculture (Bulletin No. 845, Production of Lumber, Lath, and Shingles in 1918, by Franklin H. Smith and Albert H. Pierson, Statistician in Forest Products, p. 13), from which have been drawn the figures of production during the years 1916, 1917, and 1918. Through the courtesy of the United States Bureau of the Census, it has been possible to present the figures of production in each of the tributary States during the year 1919—information which has not yet been made public; and through the courtesy of the Secretary of Agriculture it has been made possible to present the figures of lumber production in each tributary State during 1920.

According to the most authoritative statistics available, it is possible to estimate the value of the lumber, lath, and shingle production of the United States for two years, 1918 and 1920, and to arrive at an estimate of the value of the production of the States of the tributary area. This makes possible a comparison with the total valuation of the entire lumber production of the United States.[1]

In 1918 the value of the lumber produced in the entire United States was placed at $739,598,774. That produced in the tributary States during the same year was valued at $151,417,400 or 20.5 per cent of the entire country.

In 1920 the lumber production of the entire United States was placed at $1,298,899,107, of which $235,759,347, or 18.2 per cent, was produced in the States of the tributary area.

These data are presented in tables which have been compiled from the only existing sources of information. The table which shows the quantity and value of lumber production in 1918 was compiled from reports of the Forest Service, which show the quantity of each kind of wood produced in each State, and from reports of the Bureau

[1] See Appendix B1.

of the Census, which show the average value of each kind of lumber during the same year for which the Forest Service figures are presented. This combination results in an approximation of the value of the entire lumber production of the States of the tributary area, and may be accepted as a safe estimate. By combining the quantity figures of the Forest Service with the valuation figures of the Bureau of the Census, it has been possible to present in the table a parallel comparison of the total valuation of the various kinds of wood produced in the tributary area, with the result stated above, namely, that the lumber products in 1918 of the tributary area represent 20.5 per cent of the entire lumber products of the United States.

For the year 1920 it has been possible—through the courtesy of the Secretary of Agriculture in furnishing recent and authoritative data—to present the Forest Service's valuation of lumber production, by States. These figures are presented in comparison with the figures for the year 1918, and show that in 1920 in tributary States produced 18.2 per cent of the lumber of the entire United States.

The total area of merchantable timber on the farms of the United States amounted, in 1919, to 35,270,527 acres, of which 11,173,103 acres, or 33.2 per cent of the total, fell within the States tributary to the Great Lakes and St. Lawrence. No reports are available regarding the number of board feet represented by this acreage.

These figures are from the preliminary reports of the United States census of 1919.[1]

The annual pulpwood consumption of the United States averaged for the four-year period, 1917 to 1920, 5,580,694 cords, of which 2,380,980 cords, or 42.7 per cent of the total, represented the consumption of the area tributary to the Great Lakes and St. Lawrence. The average annual value of the total consumption, for the same period was $84,465,994, of which $36,054,090 (also 42.7 per cent of the total), applied to the tributary area.[1]

The territory here included in the tributary area is composed of Wisconsin, Minnesota, Michigan, Ohio, and New York. The entire product of New York, most of which falls in the tributary area, is included, but the entire product of Pennsylvania and West Virginia, a large part of which falls in the tributary area, is excluded. It is believed that this gives a conservative estimate for the tributary area.

The figures cited are all derived from the Report of the United States Department of Agriculture, Forest Service, entitled "Pulpwood consumption and wood-pulp production, 1920."

For the four-year period 1917 to 1920, the average annual production of wood pulp in the United States amounted to 3,540,854 tons, of which 1,553,876 tons, or 43.9 per cent came from territory tributary to the Great Lakes and St. Lawrence. The total value at the mills of the total production noted amounted to $200,471,779, of which $81,608,684, or 40.7 per cent, applied to the production of the tributary area.[1]

In these computations the States counted as within the tributary area are Wisconsin, Minnesota, Michigan, Ohio, and New York. Part of the wood pulp production of New York State may not prop-

[1] See Appendix B1.

erly belong within that area, but it is believed that this possible error is more than balanced by the exclusion of Pennsylvania, with a production of some 400,000 tons per year.

For the year 1919 data regarding value are not reported. Therefore, the averages regarding value of product quoted above are based on a three-year period, whereas production is based on a four-year period. That the omission of value data for 1919 does not seriously affect the average is indicated by the fact that the percentage of value of the production of the tributary area to total production for the United States was 41.1 in 1917; 39.3 in 1918; 44.3 in 1920; and 40.7 for the three-year average.

All figures cited are derived from the report of the United States Department of Agriculture, Forest Service, on "Pulpwood consumption and wood-pulp production, 1920."

In the year 1919 the total production of paper of all kinds in the United States was, according to the United States Census, 6,125,990 tons (2,000 pounds) with a value of $704,325,135. Of this total quantity produced, 3,348,317 tons, or 54.7 per cent, was from the States within the tributary area; and of the value of the toal production, $356,712,022, or 50.6 per cent, applied to the tributary area.[1]

In computing the production to be included within the tributary area, the State of New York, with most of its production in the northern part of the State, was included, but to balance any error resulting from including the whole production of New York, the States of Pennsylvania (with a large production) and West Virginia (with a small production) were entirely excluded.

The figures cited were taken from an as yet unpublished report of the Census Bureau. Data for other years than 1919 are nowhere available.

From 40 to 45 per cent of the manufacturing in the United States is done in the area tributary to the proposed waterway. Furthermore, the tributary area is growing in importance as regards manufactures faster than the rest of the country, for the rate of increase in the tributary area has been markedly greater than the portion of the United States outside the area. This increase has been remarkably consistent. It shows up in all three sets of figures, viz, capital invested, value of products, and value added by manufacture, both for the period 1909-1914 and for 1914-1919.[1]

In 1919, there was invested in manufacture in the tributary area upward of $19,000,000,000, which was 42.6 per cent of that in the whole country. The value of the products was $28,500,000,000, and the value added by manufacture during the year 1919 was over $11,000,000,000.

The figures are taken from United States Census Reports and are given by States in the accompanying tables.

As indicated by other tables presented in the appendix, the larger part of the raw materials of manufacture in the United States comes from the tributary area, and therefore the proportion of the total produced by the area in question should increase in future years rather than decrease.

A study of the sources of the basic raw materials of manufacture reveals the fact that the tributary area is fairly well self-contained.

[1] See Appendix B1.

The bituminous-coal fields of Pennsylvania, West Virginia, Ohio, Indiana, Illinois, Iowa, and Wyoming give all sections of the area a plentiful and near-at-hand supply of high-grade fuel for power development. The Lake Superior region furnishes the great mass of the iron ore of the Nation and a considerable part of the copper and other metals. Thus the tributary area has natural advantages in the development of such metal-working industries as automobile manufacture, foundries and machine shops, etc., not enjoyed by areas farther removed from the sources of power development and raw materials.

As indicated by the table showing values of animals sold or slaughtered on farms,[1] much the greater part of the animals slaughtered in the slaughtering and meat-packing industries comes from the great corn-producing region embracing Ohio, Indiana, Illinois, Iowa, Missouri, Kansas, and Nebraska. Also it is natural that the great flour-milling industry should be centered near such great wheat-producing States as the Dakotas, Kansas, Minnesota, Nebraska, Missouri, Illinois, and Indiana. An inspection of the tables of agricultural production,[1] with special reference to the production of corn, wheat, all crops and dairy products, emphasizes the fact that the tributary area is better adapted to the support of a large manufacturing population than any other region of the country.

The table of production of the leading industries of the United States shows that between 1914 and 1919 the per cent increase was 143.4 of the slaughtering and meat-packing business; 206.2 per cent of the iron and steel, steel works, and rolling mill business; 374.5 per cent of the automobile manufactures; 160.9 per cent of the foundry and machine shop works; and 149.9 per cent of the flour and grist mills were contained in the tributary area. As regards manufacture for export, this area is particularly favored, more especially as regards food products, for most of the slaughtering and meat packing and flour and grist milling done outside the area is for local consumption rather than for export.

As indicated by the large comparative table of manufacturing industries in the United States,[1] 24 per cent of the boot and shoe manufacture, 27.9 per cent of the leather tanning, and 34.3 per cent of the manufacture of men's clothing was, in 1914, contained in the tributary area of the proposed waterway. The detail tables for certain industries which follow [1] show the production by States of the tributary area and the proportion of the total production of the United States contributed by the tributary area.

During the year 1920 a total of 1,255,704,973 tons of freight traffic originated on all class 1 railroads in the United States, according to a statement issued by the Interstate Commerce Commission. It is estimated that 703,639,440 tons, or 56 per cent, of this traffic originated in the tributary area of the proposed waterway.[1]

This total is the traffic originating (traffic received from connecting lines is excluded) on Class I railroads only. In addition, there is a much smaller amount of railroad traffic which originates on Class II and III railroads and on switching and terminal railroads, all of which is excluded from the above figures. Also a considerable amount of package freight is handled by the express com-

[1] See Appendix B1.

panies and the parcel-post service, none of which is included in the above figures. There is also the water-borne freight of all kinds and an uncertain amount of short radius freight carried by motor trucks and wagons. Pipe lines also are used for the transportation of petroleum. However, the great mass of railroad traffic is included in the figures given.

As indicated by the appended table, the freight reported on the statement is segregated into classes of commodities which has enabled the proportions of the commodities originating in the tributary area to be estimated with varying degrees of correctness. The apportioning factors used for the several commodities have been determined upon the basis of production, the source of the figures being given in the last column.

The table is of value as giving a general idea of the amount and nature of the railroad traffic originating in the tributary area of the proposed waterway. Its use for particular commodities is limited by the reliability of the information upon which the apportioning factor is based. In certain instances, such as salt or asphaltum, in which a considerable portion of the railroad traffic is made up of shipments of imports from ports of importation, the factor based upon the proportions of the domestic production produced in the tributary area is unreliable. In the case of other, and generally much more important commodities, like coal, wheat, domestic animals, structural steel, etc., the results should be fairly reliable.

The products of agriculture and products of animals being based mostly upon the 1920 census figures, should be fair estimates of the amount of traffic originating in the tributary area, particularly as the area in question produces around 50 per cent of the total agricultural production of the country. Exception is made of wool and hides and leather, in which imports impair the correctness of apportioning factor. The figures for flour and grist mill products in the tributary area are probably smaller than they should be. The large commercial flouring mills whose product is shipped on the railroads are located in Minnesota, whereas much of the production of local gristmills, whose proportion of the total production falls largely outside the area, is hauled away from the mills in wagons.

The products of mines are not as easily handled. The 98,000,000 tons of "clay, gravel, sand, and stone" are probably not very accurately reported, and the stone is reported in dollars of value, while the clay, gravel, and sand are reported in tons. The value of the stone was converted into the equivalent number of tons by the use of an average value per ton of stone, after which it was added to the clay, sand, and gravel, and the apportioning factor computed from the result. Iron ore is satisfactorily handled on basis of production, but "other ores and concentrates," amounting to nearly 22,000,000 tons, is made up of an indefinite number of ores in various states of refinement, and no satisfactory basis of apportioning is apparent. Salt and asphalt are complicated by imports, but are rather small and do not affect the grand total greatly. "Base bullion and matte" is of negligible tonnage. The other items, as coal, coke, and crude petroleum, are satisfactorily apportioned on the basis of production as indicated.

Among the products of mines, the item "other ores and concentrates" is apportioned on the basis of total production of copper,

lead, and zinc, the figures for copper being given in pounds and those for lead and zinc in tons, the pounds of copper being changed into tons before totaling. The item "clay, gravel, sand, and stones" was apportioned on the basis of the 1918 United States Geological Survey figures for the production of raw clay in tons, sand and gravel in tons, and value of the production of stone in dollars, the latter being converted into tons before totaling by the use of an average value per ton for the United States for the year 1918.

Coke, bituminous coal, iron ore, and petroleum are apportioned on the basis of production. In addition to the bituminous coal transported by railroads nearly 14,000,000 tons was transported in 1916 by barges on the Ohio River and its tributaries. Likewise, an unknown quantity of petroleum was carried by pipe lines. The figures for iron ore probably are complete, as the ore from the Lake Superior field is carried from the mines to the docks in railroad cars. The accuracy of the apportioning of asphaltum and salt, being based upon domestic production, is impaired because of imports.

The statistics of products of forests are comparatively unsatisfactory, so the total amount, over 100,000,000 tons, has been apportioned on the basis of production, the figures for which are far from precise, thus causing uncertainty as to the portion of this tonnage originating in the tributary area.

Manufactures are mostly apportioned upon the basis of value of products according to the 1914 census, the figures for the 1920 census not being yet available. The item for "other metals, pig, bar, and sheet" is apportioned on the basis of the smelting of copper, lead, and zinc according to the 1914 census. The figures, which are those for value of product in dollars, are converted into tons before totaling by the use of average prices per ton of these metals in the United States in 1914 as computed from the figures of the United States Geological Survey.

The figures for sewer pipe and drain tiles are from the figures of the United States Geological Survey for clay products which, in addition to sewer pipe and drain tile, include brick, terra cotta, and other products. It is believed the figures apportioned to the area are much too small.

The figures credited to the tributary area for ice, being based upon those for manufacture of ice in 1914, are doubtless too small, for a goodly proportion of the ice shipped on the railroads in the northern part of the United States is cut from lakes and streams, whereas ice shipped in the South is manufactured. Also due to the warmer climate in the South, which is outside of the tributary area, the requirements for ice there are greater.

The item of "Household goods and second-hand furniture," being doubtless due to the moving of families from one place to another, is divided on the basis of total population. The 75.6 million tons of other manufactures and miscellaneous in carload quantities is divided on the basis of the total value of manufactures according to the 1920 census. The 53,000,000 tons of less-than-carload merchandise, being package freight originating largely at the distributing centers, is divided upon the basis of total population according to the 1920 census.

PRODUCTION OF TRIBUTARY AREA IN CANADA.

Differences in statistical methods, and in some cases lack of data, make it difficult to present tables for the tributary area in Canada exactly corresponding to the foregoing tables covering the tributary area in the United States. It is believed, however, that the Canadian statistical tables in the appendix[1] will give a fairly comprehensive idea of the resources and production of the four tributary Provinces—Ontario, Manitoba, Saskatchewan, and Alberta.

As will be seen by a glance at these tables, they cover grain production and grain value, quantities of wheat exported, live-stock values, value of dairy-factory products, forest resources, and quantities and values of forest products, quantities and values of wood used for the manufacture of pulp, and quantities of pulp produced and paper manufactured, value of mineral production, quantities of coal production and copper production, production of cement, value of fisheries, capital invested in manufacturing, cost of materials used in manufacturing, value of manufactured products, railway mileage, and railway traffic originating in the Canadian tributary area.

Grain production and values are shown for the five years 1916–1920, with separate figures for wheat, oats, barley, corn, rye, flax, buckwheat, peas, beans, and mixed grains, with totals for all grains and the average production and values for the 5-year period.

It will be observed that the average production of wheat in the Canadian Provinces for the five years was about 222,300,000 bushels, this being considerably under the totals for 1916 and 1920, as 1918 and 1919 were lean years. The average production of all grains for the five years was approximately 696,000,000 bushels, valued at over $760,000,000.

The exports of wheat during the same period averaged, in round figures, 131,500,000 bushels, or, deducting the quantities shipped to the United States, about 109,800,000 bushels. Nearly a hundred million bushels of this went to the United Kingdom. It will be noted, however, that this average is built up by war exports in the years 1915–16, 1916–17, and 1917–18, the figures dropping rapidly in the succeeding years, the exports in 1918–19, for instance, being less than one-quarter of those in 1916–17.

Farm live-stock values in the tributary Provinces between 1916 and 1920 averaged about $819,000,000, of which Ontario contributed considerably more than one-third.

In dairy-factory products Ontario represents an overwhelming proportion of the total, or over $58,600,000 worth out of an average value of $71,600,000. It is noticeable, however, that all four tributary Provinces show a steady increase in this branch of production during the 5-year period.

In forest products figures are available for the tributary Provinces for the years 1917, 1918, and 1919, the average production of lumber being valued at about $34,500,000, of shingles $330,000, and of laths at $723,000. For the same period the average quantity of wood used in the manufacture of pulp amounted to 787,000 cords, valued at about $10,300,000. The average quantity of pulp pro-

[1] Appendix B3.

duced was over 531,000 tons and of paper manufactured nearly 436,000 tons. These figures all relate to the Province of Ontario, the three prairie Provinces producing neither pulp wood, pulp, nor paper.

Of the forest resources of the tributary Provinces, Alberta is credited with a total of 100,000,000,000 board feet of hardwood and softwood; Saskatchewan, 82,800,000,000 board feet; Manitoba, 44,510,000,000 board feet; and Ontario, 185,550,000,000.

The estimated timber resources of the Canadian tributary area amounted to 412,860,000,000 board feet. This estimate was made in July, 1921, by the commission of conservation of Canada. It is based on reconnaissance field surveys of several Provinces, examination of the returns of cruisers by lumber companies and private individuals, and the latest information from both Dominion and provincial Government officials.

On the basis of an annual production of 4,000,000,000 board feet, the virgin saw material in Canada will be used up in about 140 years and that now considered accessible in 70 years.

About 38 per cent of the pulp-wood resources of Canada are considered accessible at the present time. At the present rate of cutting the accessible supply will last about 100 years, provided all is used for pulp.

The Panama Canal route is now a serious competitor with the railways in timber shipments from the Pacific coast to eastern Canadian points. Timber shipments via Panama from British Columbia successfully compete with the all-rail and the rail-and-lake route as far inland as Montreal.

The mineral production of the tributary Provinces for the period 1916–1920 has an average value of about $107,700,000, of which over $82,000,000 belongs to Ontario. Alberta comes next with $21,500,000, the production in the other two Provinces being comparatively small. Ontario's total is made up mainly of gold, silver, copper, and nickel. That Province possesses no coal, but there are very large resources of low-grade iron ore awaiting development.

The average production of coal in the tributary Provinces during the five-year period was 5,760,000 short tons, of which amount Alberta contributed 5,400,000 tons and Saskatchewan the balance.

The production of copper in the tributary area in Canada between 1916 and 1920 averaged about 41,500,000 pounds, of which 39,600,000 pounds came from Ontario and the balance from Manitoba.

The three Provinces of Ontario, Manitoba, and Alberta produced an average of 2,400,000 barrels of cement in the five-year period, of which the major portion was again contributed by Ontario.

The tabulation of fisheries in the Canadian area shows an average production during the three years 1917–1919 valued at $5,300,000, Ontario's proportion being about three-fifths, Manitoba's about one-fourth, the figures for Saskatchewan and Alberta being very much smaller.

As regards manufacturing, figures are available for the years 1910, 1915, and 1918. The capital invested in manufacturing in the four tributary Provinces increased from about $680,000,000 in 1910 to about $1,700,000,000 in 1918. The cost of materials used in manufacturing increased from about $341,000,000 in 1910 to $1,187,000,000

in 1918, and the value of manufactured products increased from $658,600,000 in the former year to $2,086,000,000 in the latter.

As to railway traffic originating in the Canadian tributary area, this information has only been segregated by Provinces since July, 1920. The figures are now available for the year ended June 30, 1921, the total tonnage for Ontario being 20,083,964; for Manitoba, 4,591,055; for Saskatchewan, 4,985,545; and for Alberta, 7,589,644; or a total of 37,250,208 tons for the Canadian tributary area.

TRANSPORTATION SITUATION IN UNITED STATES.

Having discussed the character and extent of production in the areas economically tributary to the proposed waterway on both sides of the boundary, it will be convenient now to take up the question of how the surplus of this production available for export finds its way to the seaboard, and particularly why it has become necessary to secure additional means of transportation.

In Part III the substance was presented of a great mass of testimony put before the commission at its various hearings tending to show that the commerce and development of the tributary area in the United States had been seriously affected by congestion on the railways, and particularly at certain points known as "bottle necks," as well as at the Atlantic terminals. This subject is also dealt with at some length in the studies of Messrs. MacElwee and Ritter. The following pages are intended to supplement these sources of information, particularly in regard to the present needs of the railways of the United States in equipment and other betterments, what these needs would involve in the way of capital expenditures, and the ability of the railways to raise the enormous sums involved within a reasonable period.

The relationship of these studies to the present problem is obvious. If the tributary area in the United States is increasing so rapidly in population and production and foreign trade that it is impracticable for the railways to keep pace with that increase, the obvious remedy is to develop other transportation facilities that will meet the needs of the West by lifting some of the burden from the railways. Such a transportation facility is the proposed water route to the Atlantic seaboard.

At the present time the railroads of the United States are suffering from the general business depression. No one, however, expects this condition to continue, and plans for the future must be conditioned upon the knowledge that sooner or later traffic will be restored to normal. Normal, in this sense, means substantially the traffic carried in 1920 with a steady increase with the growth of the country in population and commerce.

Such being the prospect, it becomes a matter of vital public importance to know whether the railroads are in a position to assume this burden when it shall be placed upon them; whether, in other words, the railroads have developed their carrying capacity, trackage, and terminal facilities to the point necessary to handle the traffic which they will be called upon to handle when business resumes its former activity.

The weight of opinion, supported by the weight of statistical evidence, is that the railroads are not equipped for the work in prospect

and that this underequipment can only be remedied by large expenditures for additions and betterments. Certain critics of the railroads argue that great economies can be effected by increased operating and administrative efficiency. There may be truth in this criticism, even if no more could be accomplished than to bring the operating standards of all roads up to those of the best roads; some money doubtless could be saved and more work done with the same equipment. It would seem, however, that the economies effective from this source could make up only in relatively small part for the lack of sufficient and proper equipment necessary to carry the normal peak loads of traffic. Thus, representatives of the employees, in arguing before the Railroad Labor Board in May of this year, placed great stress on the inadequacies and inefficiencies of railroad management, but they conceded that very heavy expenditures for additions and betterments were absolutely necessary if the railroads were to perform their functions successfully and economically. (See employees' exhibit before the Railroad Labor Board, May, 1921, entitled "Inadequacies of management," Pts. I–IV.)

Looking at the problem from an entirely different angle, Mr. L. F. Loree, president of the Delaware & Hudson Railway Co., suggests (Railway Age, Jan. 2, 1920, p. 12) that the proper solution of the railroad problem of handling the "peak load" involves no less than the abolition of the peak load by regularizing traffic so that the railroads can obtain the maximum use of their equipment throughout the year. This could be accomplished by an insistence on adequate reservoiring of the grain, bituminous coal, ore, and kindred traffic largely seasonal in character. This would enable the railroads to handle their traffic with a much less equipment than is required now when at certain seasons much equipment is completely idle. If such a regularization of traffic could be effected it would undoubtedly be of tremendous value in reducing the equipment needs of the railroads. Practically, however, there seems little hope of the actual application of such a scheme on an important scale, as it would require too many radical changes in the habits and customs of producers, distributors, and consumers.

With scattered exceptions of this character, the great body of opinion, whether friendly or hostile to the present system of railroad administration, agrees in holding that the railroads are in need of extensive additions and betterments and that this will require large outlays of capital. Thus as regards the lack of efficient equipment, the recent testimony of Mr. Daniel Willard, president of the Baltimore & Ohio Co., before the Interstate Commerce Committee of the United States Senate in May, 1921, is of particular interest. According to Mr. Willard, the railroads, in 1920, were not able to handle the traffic offered in an economical way; they were working beyond their capacity, with the result that additional business was carried at a disproportionate cost per unit. His attitude is illustrated in the following excerpts from his testimony:

> I appreciate fully that increased business yields a much larger net return, perhaps 50 per cent of the increased business would be net. But that is only when the carriers are working well within their economic capacity. Now, it so happened in 1920 that the carriers, in the East at least, were working under the most extravagant circumstances and beyond their economic capacity. * * * Perhaps as good an illustration as any would be this: Last October the

Baltimore & Ohio paid more than $2,000,000 for overtime to trainmen, trackmen, and different employees in its service. In March of this year the payments for overtime were $360,000, as I recall, or substantially a reduction of 81 per cent. The point is this, that we had so many trains on the road that they got in each other's way, resulting in delays, more accidents, and the men were tired, and the whole operating process was bad railroading, because we were trying to put a quart in a pint cup, and could not do it." (Committee on Interstate Commerce of the United States Senate. May 16, 1921; part 4 of hearings, p. 161.)

This in general seems to have been the attitude of railway executives not only during and since the war, but also for a number of years before the war. Thus in the hearings before the Interstate Commerce Commission in what is known as the Advance Rate cases of 1910 (p. 29) President E. P. Ripley, of the Atchison, Topeka & Santa Fe Railroad, declared:

There is no railroad in this western country—I will not say that—there is hardly any railroad in this country to-day that is built as it ought to be built, that has the safety appliances that it ought to have or that is in the condition that the public interests require. I think all my railroad friends will bear me out in making that statement. Of course, we do not like to depreciate our own property, but the best railroads in this country west of the Allegheny Mountains are very, very far short of what they ought to be to give the service that the public requires and has the right to demand, or would have the right to demand if they paid for it.

Again, in 1917, just prior to the entrance of the United States into the war, President Smith, of the New York Central Railroad, stated:

How much the limited capacity of our transportation lines may have contributed to present high prices no one can tell. If we had been able to do many of the things that we know needed to be done, the capacity would now be much greater. But the capital was not to be had, at least at rates which we could afford to pay. (Fifteen Per Cent case, Ex Parte 57, vol. 8, p. 230.)

At the same hearings, 1917, President L. E. Johnson, of the Norfolk & Western, expressed the following opinion regarding the adequacy of the railroad equipment:

My study of the situation that now prevails leads me to the conclusion that it is not so much a shortage of freight cars that causes this condition as a shortage of motive power first, and second, the inadequate facilities that exist in every important city in the United States. That is what is holding the cars there from doing their normal work. If the roads of this country had had the money in the past and could have expended it for increased facilities, such as double tracks, yards, terminals, etc., a condition of this sort would not concern you to-day as it does. (I. C. C. Ex Parte 57, vol. 7, pp. 93, 94.)

To the same effect President Samuel Rea, of the Pennsylvania Railroad, stated at the same time that failure to provide for the additional transportation facilities and service—

means curtailment of expenses and capital expenditures in a period of the greatest demand for railroad transportation service this country has ever known. The lack of sufficient surplus for many years past has prevented the railroads from providing such additions and improvements in advance of traffic demands. (I. C. C. Ex Parte 57, vol. 7, p. 14.)

Vice President A. W. Thompson, of the Baltimore & Ohio Railroad, in the course of his testimony noted that:

For the past 10 years the Baltimore & Ohio has been spending for betterments, including equipment, an average of $18,000,000 per year. Even this expenditure has not been large enough to keep up with the development of the business of the Baltimore & Ohio, and during the past year lack of terminal facilities, equipment, and certain needed improvements along the line of road has been very keenly felt. (I. C. C. Ex Parte 57 (1917), vol. 8, pp. 346, 347.)

These citations indicate clearly that in the view of at least certain prominent railroad officials, the difficulties of the railroads were not primarily due to sudden war-time emergencies, but were the result of a long period of time during which railroad additions, betterments, and maintenance had failed to keep pace with the demands of an expanding traffic. While it is possible that the attitude of the railway officials may have been influenced in some degree by the fact that they were at the same time asking for increased transportation rates, it is not conceivable that such positive statements could have been made by responsible officials unless conditions were substantially as described by them. Moreover, impartial observers had reached practically the same conclusions. Thus Commissioner Daniels of the Interstate Commerce Commission wrote in 1917:

> The ultimate fact is that the American railways as a whole are at present unable to handle the total volume of American commerce at peak load. * * * The essential cause of this unpreparedness is that in recent years the requisite additions to equipment and facilities have not been made. * * * It appears indisputable that the capacity of our rail transportation system as a whole has been falling astern the growth of population and the demands of traffic. (Railway Age, Jan. 5, 1917.)

The banking and financial interests take a similar view. Thus the National City Bank Bulletin, June, 1920, pp. 4–5, says:

> Every industry needs more capital to-day, but not one needs it more desperately than the transportation industry. The railroads' problem is the more acute because they must make up past deficiencies as well as prepare for future needs. A progressive management endeavors to keep from five to seven years ahead of actual traffic demands. To-day the railroads are far behind current demands. The blame for this situation rests on the public, not on the railroad management. After the adverse decision in the 1911 rate cases the amount of new money which the railroads were able to raise by the sale of their securities steadily diminished.

Indeed, there seems to be little or no dissent from the opinion that the railroads for a considerable period at least have been underequipped and underdeveloped. There is much discussion and even heated controversy as to where the blame should be put—whether the fault has been due to financial and administrative mismanagement or to circumstances over which the railroads had no control. The merits of this controversy have no place here. The only point of present interest is that, without regard to where the responsibility for such conditions should properly be placed, the railroads are underequipped to meet the needs of the country's business.

Granting, then, the needs of the railroads for extended additions and betterments if they are to be made equal to the transportation demands of the country, two questions arise: First, precisely what is needed and what the cost would be, and, second, whether the amount of money needed can be secured.

As regards the cost of necessary improvements, experienced railroad men, financiers, and students have made estimates varying from $1,000,000,000 to $2,000,000,000 per year over a series of years. Upon this point Mr. Julius Kruttschnitt, chairman of the Southern Pacific Co., speaks from a long and wide acquaintance with railroad affairs. He says:

> The average annual capital expenditures for the construction of new and the betterment of existing lines for the 10 years preceding 1917 was about $660,000,000, but as the purchasing power of the dollar has declined, at least

twice this amount, or $1,320,000,000, per annum, will be needed to provide what the smaller sum did formerly. In the years 1918–19, under Government control, $806,000,000 only was spent. (Annual Report of the Director General of Railroads for 1919.) As the normal expenditures for the two years should have been $2,640,000,000, capital expenditures were short $1,834,000,000 on January 1, 1920, and this amount, in addition to the normal annual sum of $1,320,000,000, should be spent in 1920 to catch up, and $1,320,000,000 should be spent annually thereafter, subject, of course, to reduction ratably with any rise in the purchasing power of the dollar and in the efficient use of existing facilities. (Railway Age, Jan. 7, 1921, p. 17.)

President Willard, of the Baltimore & Ohio, is somewhat more conservative, placing the capital expenditure needs at $1,000,000,000 per year:

If this country were fully developed and if we had already reached the peak load which the railroads will be expected to carry, the railroad problem would be a much simpler one than it is under conditions as they actually do exist. Our country has not stopped growing. It is far from being fully developed. Experience of the past demonstrates clearly that at least $1,000,000,000 per annum must be provided as a minimum for capital expenditures for new equipment and facilities necessary to keep the railroads abreast of the transportation requirements of the country. (Address, Dec. 9, 1920.)

Probably the most careful and detailed analysis of the needs of American railroads in capital expenditure is that made by the Railway Age and published in its issue of January 2, 1920. This study was made by engineering experts employed by the Railway Age and is based upon their investigations and upon the statistics of the Interstate Commerce Commission. The conclusion of this study was that the needs of the railways were such as to require capital expenditures of slightly over $6,000,000,000 during the succeeding three years. The following table gives the detailed estimates:

Additional main track	$1, 250, 000, 000
Grade revisions, cut-offs, elimination of curvature, etc	600, 000, 000
Engine houses and shops	250, 000, 000
Station buildings	300, 000, 000
Extensions	600, 000, 000
Signals	52, 264, 000
Freight cars	1, 662, 000, 000
Passenger cars	532, 000, 000
Shop equipment	61, 230, 000
Locomotives	702, 786, 000
Total	6, 010, 280, 000

Commenting upon these figures, the Railwage Age remarks:

It should be observed that the foregoing figures are not the estimates of the total amounts which should be spent by the railroads for new facilities during the next three years, but the total parts of what should be spent which should be charged to capital account. In other words, this estimate roughly estimates the amount of new capital which the railroads should raise and invest during the next three years to bring their facilities abreast of the needs of American commerce.

In order to show that its estimate of $6,000,000,000 was a conservative one, the Railway Age compares it with estimates made by James J. Hill in 1907:

As bad as were the congestion of traffic and car shortage in the years 1906 and 1907, they were not as bad as they have been within the last three years. In 1907, however, James J. Hill estimated that in order to put the railways

in shape satisfactorily to handle the commerce of the country there should be invested in them during the next five years a total of $5,000,000,000, or $1,000,000,000 a year. Now $2,000,000,000 would not at present wages and prices provide any more railroad facilities than $1,000,000,000 did in 1907. Therefore, our estimates as to what should be done per year for three years is no larger than Mr. Hill's estimate in 1907 as to what should be done per annum for five years.

Furthermore, it is highly interesting to note that when allowance is made for changes in prices, the estimate of the Railway Age approximates very closely the one made by the Association of Railway Executives before a joint congressional committee in 1916. This estimate of capital needs called for $1,250,000,000 per year over a period of 10 years. The method of arriving at these figures is explained as follows:

We have had that subject studied and in due time the exact methods of that study, the way it was carried on, the figures which have been deduced from it, will be presented for your consideration. I will now simply give you the method and state conclusions.

In our effort to ascertain what are the reasonable needs of the future, we have studied the growth of population, industries, and commerce during the past 20 or more years and the growth and development of railway traffic and of facilities and equipment during the same period. We have tried to show what the percentage of increase year by year has been during that period; how the property has grown, how the traffic has grown, and how the railroad facilities have grown to take care of it. The result is this, from the growth of population, industries, and commerce during this period, this has been found:

First, that the wealth of the country has increased at the rate of 8 to 9 per cent per year, and that the same ratio has held good in the demand for transportation.

Second, that the forces that have operated in this growth and development in the past apparently continue still in full operation and may reasonably be expected so to continue for the next 10 or 15 years.

Third, that the investment in railway facilities in order to meet the enlarged requirements of the future because of this continued growth and in order to fulfill the duties and obligations imposed upon the railways by the public, must therefore also proceed at a corresponding annual rate of increase.

We take, then, 8 per cent as the result of these figures to indicate the annual growth that must be provided for in railroad facilities of all sorts in order to keep up with the 8 per cent of increase in the business of the country and the result of that is that during the next 10 years there will be needed approximately $1,250,000,000 a year in order not to constrict the business and productive energies of the country and in order to supply them reasonably with the facilities which this growing business will require. Now, these figures, of course, are not accurate; these figures indicate a mere attempt to forecast within some sort of reasonable limit the needs of the railroads and the public interest annually during the next 10 years. Those figures apply only to the amount that will be required to increase your facilities; they do not contemplate the amount that will be required to refund your maturing debt. From the best information that we can obtain, there will be required to refund maturing debts during that time a sum approximating $250,000,000 a year, so that the requirements of the railroads for new money during the period to which I allude are estimated by us to be $1,500,000,000 a year. (Hearings before Joint Committee of the Senate and House of Representatives on Interstate and Foreign Commerce, under Senate joint resolution No. 60, to investigate Government control, regulation and ownership of interstate public utilities, 1916; pp. 37–39; oral argument of Alfred T. Thom, counsel for Association of Railway Executives.)

All of these, as well as other estimates of the capital needs of the railroads must, of course, be interpreted in the light of the price levels existing at the time. Thus, the Railway Age's estimate of $6,000,000,000 was made at the beginning of 1920 when prices were almost

at their peak. Since then prices in general have declined between 30 and 40 per cent. This would make the present cost of this estimate about $4,000,000,000. On the other hand, Mr. Hill's estimate of $5,000,000,000 in five years was made in 1907 when prices were some 30 per cent lower than they are now, and the estimate of the Association of Railway Executives of $1,250,000,000 per year for 10 years was made in 1916 when prices were considerably lower than at present. It is impossible to forecast with any accuracy the future trend of prices, but it seems reasonably certain that the prices of those things which the railroads buy in largest quantities will not fall on the average much below the present level, at least for a considerable period of time.

In addition to estimates of capital needs made by railroad officials and others in close touch with railroad affairs, such needs may be approximated by analyzing the statistical material contained in the reports of the Interstate Commerce Commission. This information has been made careful use of by the Railway Age in its above-mentioned study published in its issue of January 2, 1920. Most of the figures cited below are taken from this source, after checking as far as possible with the original data.

The normal growth of freight traffic in the United States is susceptible of reasonably accurate measurement, and a comparison of the number of freight cars constructed each year with the normal yearly increase in traffic will show the car needs of the railroads. The estimate of the Railway Age regarding future traffic growth is presented here. This was made in 1920 before the recent depression, and is therefore in error regarding present conditions. On the other hand, the computing principle used is a sound one, and in spite of the present depression, it is to be expected that traffic will sooner or later be restored to the upward curve it has, on the whole, been following over a long period of time, due to the steady upward curve of population and business.

The figures in the following table show the actual freight traffic from 1904 to 1918, and also the computed normal traffic from 1904 to 1926.

Since the rate of increase of the freight traffic is made up of two factors, (1) the rate of increase of the population and (2) the rate of increase of the ton-miles per inhabitant, it follows that with these two rates known the normal rate of increase in the traffic, which is the product of the two, can be determined. Furthermore, if the normal traffic for any year in the period is known, the normal traffic for the other years can be computed. The data on the normal freight traffic in this study are based on the ton-mileage for 1911, as this represents a fair average between heavy and light traffic. The normal rate of increase of the traffic, as calculated, varies progressively from 4.40 per cent in 1911 to 4.14 per cent in 1921. The table has been extended ahead to 1926 in order to show the probable traffic in future years, and backward to 1904 to demonstrate how closely the rate of increase computed checks with the average traffic during the period 1904 to 1911.

Freight traffic in ton-miles.[1]

Fiscal year.	Actual.	Normal.	Calendar year.	Actual.	Normal.
1904	174,522,000,000	186,015,000,000	1916 [2]	362,444,397,000	320,455,000,000
1905	186,463,000,000	194,735,000,000	1917 [2]	394,405,409,000	334,100,000,000
1906	215,878,000,000	203,690,000,000	1918 [2]	405,379,284,000	348,245,000,000
1907	236,601,000,000	212,990,000,000	1919 [2]	364,236,958,000	362,890,000,000
1908	218,382,000,000	222,635,000,000	1920 [2]	409,970,656,000	378,075,000,000
1909	218,803,000,000	232,640,000,000	1921		393,815,000,000
1910	255,017,000,000	243,020,000,000	1922		410,125,000,000
1911	253,784,000,000	253,784,000,000	1923		427,030,000,000
1912	264,081,000,000	264,945,000,000	1924		444,540,000,000
1913	301,399,000,000	276,515,000,000	1925		462,700,000,000
1914	288,320,000,000	288,510,000,000	1926		481,515,000,000
1915 [2]	273,913,000,000	300,950,000,000			
1916 [2]	339,870,323,000	313,840,000,000			

[1] Based on data contained in the Railway Age, Jan. 2, 1920. [2] Class I only.

In order to determine the number of cars that will be necessary to handle the estimated normal traffic for any given future year, it is necessary to consider the normal rate of increase in car capacity and the average ton-miles per ton capacity per year. The figures for recent years are as follows:

Freight car mileage and average load.[1]

Fiscal year.	Revenue car-miles per car per day.	Tons per loaded car.	Revenue ton-miles per car per day.	Average capacity of car.	Ratio average load to capacity, per cent.	Ton-miles per ton capacity per year.
1905	16.3	18.1	298	30.7	59.0	3,500
1906	17.0	18.9	321	32.1	59.0	3,650
1907	16.5	19.7	325	33.7	58.5	3,520
1908	14.6	19.6	286	34.8	56.3	3,010
1909	15.0	19.3	290	35.3	54.7	3,000
1910	16.5	19.8	327	35.9	55.2	3,320
1911	16.0	19.7	315	36.9	53.4	3,120
1912	16.2	20.2	326	37.5	53.9	3,180
1913	17.2	21.1	363	38.3	55.1	3,460
1914	16.1	21.1	340	39.1	54.0	3,180
1915	15.2	21.2	328	39.8	53.2	3,000
1916	17.8	22.4	399	40.6	55.1	3,690
1916 (calendar year)	18.5	22.8	422	41.0	55.6	3,760
1917	18.8	24.8	466	41.5	59.8	4,130
1918	17.6	26.6	469	[2] 41.9	63.5	4,090
1919 (9 months)	15.2	27.9	425	[2] 42.2	65.1	3,670

[1] From data contained in the Railway Age; 1913 to 1916 include Class I and II roads only; 1918 and 1919 include Class I roads only.
[2] Estimated.

By referring to the table of freight traffic it will be noted that the ton-mileage is high in years of abnormally heavy traffic, but decreases again when the business falls off. Although there is considerable variation in the figures, from a minimum of 3,000 in 1909 and 1916 to 4,130 in 1917, there has been no general change over this period. During the first nine months of 1919 the traffic was handled at the rate of 3,670 ton-miles per ton of capacity per year, which corresponds very closely with the figure for 1906. All the data indicates that the variation from year to year is largely due to the relation between the demand for cars and the supply.

It is evident, therefore, since 1 ton of freight-car capacity should be provided for every 3,500 ton-miles to be moved during the year, that the aggregate capacity of the cars should increase at the same rate as the traffic. This has not been the case, as is shown by the table reproduced below.

Freight traffic and car capacity.

Fiscal year.	Freight traffic, in ton-miles.	Number of freight cars.	Capacity of freight cars, tons.	Capacity in tons multiplied by 3,500.
1905	186,463,109,510	1,731,409	53,255,083	186,200,000,000
1906	215,877,551,241	1,837,914	59,059,302	207,000,000,000
1907	236,601,390,103	1,991,557	67,033,324	235,000,000,000
1908	218,381,554,802	2,089,302	72,663,665	254,000,000,000
1909	218,802,986,929	2,073,606	73,137,546	256,000,000,000
1910	255,016,910,451	2,135,121	76,578,735	268,000,000,000
1911	253,783,701,839	2,195,511	81,077,028	284,000,000,000
1912	264,080,754,058	2,215,549	82,965,418	290,000,000,000
1913	301,398,752,108	2,273,564	86,978,145	304,500,000,000
1914	288,319,890,210	2,325,647	90,977,098	319,000,000,000
1915 [1]	276,830,302,723	2,356,338	92,237,691	323,000,000,000
1916 [1]	343,099,937,805	2,326,987	92,945,535	326,000,000,000
1916 [1] (calendar year)	365,771,824,741	2,358,169	95,124,679	333,000,000,000
CLASS I ROADS ONLY.				
1916	339,870,323,675	2,236,312	90,766,094	318,000,000,000
1916 (calendar year)	362,444,397,129	2,253,111	92,280,335	323,000,000,000
1917 (calendar year)	394,465,400,493	2,301,947	95,467,054	333,000,000,000

[1] Includes Class I and Class II roads only.

Figures for the years 1908 to 1915, inclusive, do not include figures of switching and terminal companies.

In 1906 and 1907 the car capacity was not as great as the traffic. During the years 1908 to 1914 there was, on the whole, a plentiful supply of cars, which increased at a rate sufficient to keep a surplus during practically the entire period. Since that time, however, the additions to the freight equipment have been far from adequate.

In the fiscal year 1914 the traffic fell off very markedly, and the number of freight cars ordered in that year was only 80,264. The fiscal year 1915 was also a period of business depression, and since 1916 higher costs and war conditions reduced the purchases; consequently between 1914 and 1921 there was not a single year when the new cars bought were sufficient to take care of the normal increase in traffic.

Class I roads in 1918 had 2,325,562 freight cars, with an aggregate capacity of approximtely 97,000,000 tons. The increase in capacity during 1919 was probably not more than 1,500,000 tons, making the capacity at the beginning of 1920, 98,500,000 tons. Adding to this the figures for the Class II and Class III roads, which own about 2.7 per cent of all railroad freight cars, would bring the total capacity for all roads to 101,000,000 tons. Under normal conditions this capacity would be sufficient to handle an annual traffic of 354,000,000,000 ton-miles, but since the traffic in 1920 amounted to 409,000,000,000 ton-miles it is evident that there was not enough equipment to handle it in a satisfactory manner. On the basis of 3,500 ton-miles per ton of capacity per year, 1920 traffic would have required a car capacity of 116,850,000 tons, or about 15,700,000 tons

more than was available. As the average capacity of cars now built is 50 tons, this would indicate a shortage of 315,000 cars.

The traffic of 1920 was high but not very much higher than called for by the normal rate of increase, which indicated a normal traffic of about 400,000,000,000 ton-miles in 1920. On this basis the car shortage, as computed above, would have been 262,000. With the passing of the present business depression the normal expected traffic would be at least 400,000,000,000 ton-miles.[1]

In addition the railroads should provide for the necessary cars to handle future increases in traffic, to make up for deferred retirements, to care for normal retirements, etc. The total number of cars needed to meet all these requirements during the next three normal years is estimated by the Railway Age as follows:

To make up the present shortage	262,000
To provide an adequate surplus	100,000
To take care of increases in traffic	126,000
To make up for deferred retirements	49,500
To care for normal retirements	174,900
Total cars needed in three years	712,400
Annual requirements	237,500

Commenting upon this table the Railway Age says:

> This is a conservative estimate of the equipment needed only by the railroad companies of this country. The private car lines own about 200,000 freight cars and the Canadian roads have also about 200,000. If the new equipment needed by these car owners bears the same relation to the total number owned that prevails for the railroads in the United States, the car building plants of this country and Canada should be called upon to furnish 830,000 cars during the next three years.

The cost of the 712,000 freight cars thus estimated to be needed during the three-year period was estimated by the Railway Age at approximately $2,000,000,000.

The intervention of the severe business depression of 1921 postponed the immediate need of the railroads for cars, as thus estimated, but the postponement may be regarded as merely temporary, as the period of depression must sooner or later terminate. Moreover, the present period of low traffic leads to a more rapid than usual deterioration and deferment of equipment, as the roads necessarily have to economize to the maximum and can do so most readily upon these charges. The result is that the restoration of normal traffic demands is almost certain to find the railroads even more poorly equipped to handle it than they are at present.

Turning to the question of motive power, available statistics show that a large number of locomotives will be necessary to handle the normal and steadily increasing traffic. Disregarding the present traffic depression, as meaning no more than a postponement of the railroads' needs, the estimates made by the Railway Age (Jan. 2, 1920) may be taken as indicating the requirements of the railroads as regards locomotive building and replacement. These estimates and the reasons advanced for them are summarized in the following paragraphs.

[1] The above computations regarding car supply are based on conditions at the beginning of 1920, as no later figures are readily available. It is known, however, that the increase in cars during 1920 was slight and not sufficient to make up for any appreciable part of the existing deficiency; and that during 1921 the roads have been practicing the most rigid economies. (See Railway Age, Jan. 7, 1921, p. 144.)

During the war a great many locomotives were continued in service that would probably have been retired under normal conditions. At a low estimate the deferred retirements would amount to 5,000 locomotives and regular retirements to 7,000 locomotives of an average tractive power of about 24,000 pounds for the next three years. This makes a total of about 290,000,000 pounds of tractive power to be built to replace deferred and regular retirements.

Had the average tractive power of locomotives increased in recent years only at the same rate as in the decade just prior to the European war the average tractive power of locomotives to-day would be 38,000 to 40,000 pounds, and it would require about 18,000 of such units to furnish the amount of new motive power required. However, the tendency has been to greatly increase the power of each unit, and on the basis of locomotives built recently it would require 7,542 freight locomotives of 60,000 pounds average tractive effort, 3,218 passenger locomotives of 44,000 pounds average tractive effort, and 2,417 switching locomotives of 40,000 pounds average tractive effort to handle the increase in traffic and to replace obsolete locomotives which should be retired during the next three years, making a total of 13,177 locomotives of modern design that should be built in the three-year period.

If the normal rate of increase in motive power which took place during the decade ending with the year 1914 had continued without interruption during the succeeding years the aggregate tractive power available at the end of the year 1918 would have been about 3,430,000,000 pounds. The actual aggregate tractive power available on December 31, 1918, was 3,196,648,349 pounds, a shortage of 35,600,269 pounds. If the retirements of unfit and obsolete locomotives had been made at the same rate as in the years prior to 1914 this shortage would probably have amounted to 350,000,000 pounds.

Based upon these estimates as regard the number of locomotives needed during the next three years of normal activity, the following estimates of cost are computed:

Normal increase in pound tractive power:	
Freight locomotives	261,928,000
Unclassified locomotives	8,099,000
Passenger locomotives	81,988,000
Switching locomotives	55,985,000
Total	408,000,000
Deferred and normal retirements in pound tractive power:	
Freight locomotives	190,472,000
Passenger locomotives	59,613,000
Switching locomotives	40,712,000
Total	290,797,000
Cost of replacing retirements:	
3,175 freight locomotives	$260,350,000
1,332 passenger locomotives	79,920,000
1,017 switching locomotives	40,680,000
Total	380,950,000
Cost of retirements when built:	
9,320 freight and unclassified locomotives	142,400,000
2,760 passenger locomotives	41,700,000
1,920 switching locomotives	21,300,000
Total	205,400,000

	Tractive power.	Number of locomotives.	Cost.
	Pounds.		
Normal increase and retirements	407,999,000	7,653	$527,254,000
Deferred retirements	290,797,000	5,524	380,950,000
Total	698,796,000	13,177	908,204,000
Average per year for three years	232,599,000	4,392	302,735,000

The cost of locomotives to be retired is taken as equal to the cost in the year 1905, when freight locomotives cost $15,250, passenger locomotives $15,100, and switching locomotives $11,100. This will retire from service locomotives costing $205,400,000 when built, and the capital expenditures of the railroads for locomotives will therefore be $702,804,000 in three years, as shown below:

Total cost of locomotives to be built in three years	$908,204,000
Total cost of locomotives to be retired in three years	205,400,000
Addition to capital expenditures	703,804,000

The stagnation in railroad development is further indicated by the decrease in the mileage of new lines constructed. During 1919 a total of 685.98 miles of new railway lines was completed and placed in service in the United States. This establishes a new low record since the Civil War, the lowest previous record being 722 miles constructed in 1918. The following table shows the miles of new line (first track) completed in the United States since 1893:

Miles of new line (first track) completel in the United States since 1893.

1894 1,760	1901 5,368	1908 3,214	1915 933
1895 1,420	1902 6,026	1909 3,748	1916 1,098
1896 1,692	1903 5,652	1910 4,122	1917 979
1897 2,109	1904 3,832	1911 3,066	1918 721
1898 3,265	1905 4,388	1912 2,997	1919 686
1899 4,569	1906 5,623	1913 3,071	1920 314
1900 4,894	1907 5,212	1914 1,532	

As great as has been the reduction in new mileage constructed during the last few years, the situation becomes even more serious when an examination is made of the miles of line abandoned during the same period. Thus a total of 535 miles of line are reported as abandoned in 1920, exceeding by 221 miles the total track constructed during that year. Operation has been discontinued on over 1,300 more miles of line than have been built during the last four years. During the three years from 1917 to 1919, inclusive, operation was abandoned on 4,032 miles of line, and in the same period only 2,700 miles of extension, branches, and other new lines were completed and placed in service.

The above figures are for new first track. Equally striking, however, are the figures for construction of second, third, and other trackage, as this secondary trackage bears directly upon the operating efficiency of the railroads. For second track, new construction fell from 682 miles in 1918 and 405 in 1919 to but 91 in 1920; and only 2 miles of third track were built in 1920 as compared with 77 miles in 1918 and 28 miles in 1919.

The mileage in the eastern district, where the congestion has been the greatest, shows a continual decrease since 1915, as will be seen from the following:

	Total mileage owned (single-track).	Eastern district.	Southern district.	Western district.
	Miles.	*Miles.*	*Miles.*	*Miles.*
Dec. 31, 1918	253,528.87	61,016.63	51,428.24	141,084.00
Dec. 31, 1917	253,626.13	61,120.98	51,405.65	141,009.50
Dec. 31, 1916	254,045.83	61,141.56	51,572.71	141,331.56
June 30, 1916	254,250.62	61,243.19	51,620.39	141,387.04
June 30, 1915	253,788.64	61,361.34	51,373.03	141,054.27

The needs of the railroads for additional trackage, motive power, and cars are thus seen to be pressing. But even still more important, perhaps, though less evident to superficial consideration, is the problem of terminal facilities. The terminal is the heart of the present transportation problem. The Railway Age (Jan. 2, 1920), refers to the subject as follows:

It (the supply of proper terminal facilities) probably means more to the producing and consuming public in the matter of delays, inconvenience, and transportation burdens than any other phase of transportation. Generally speaking, cities and railroad traffic have outgrown existing terminal facilities. The outstanding shortcoming in railroad transportation is inadequate terminals, and there can be no successful solution of the railroad problem which does not provide for their betterment.

And again in the same article:

One of the weak links in the chain of American preparedness has been an insufficiency of terminal facilities, notably in the East. The great transportation lesson learned through the experience of the war has been that the railroads have not kept pace in their outlay for rolling stock and terminal facilities with the growing needs of the public, even aside from the war emergency.

Inadequate terminal facilities mean congestion of traffic and may easily overbalance the economies incident to better track, better engines, better cars, and better loading. The seriousness of the situation was accentuated during the war when speed of distribution was particularly important and when, at the same time, the high cost of building led to a minimum amount of new terminal construction. This condition also continued in the period following the armistice. Thus the Railway Age in 1921 (Jan. 7), said:

There is no question but that the terminal, speaking in the sense of yard trackage, has been and continues to be the neck in the bottle of railway transportation. Even congestion of main tracks can frequently be ascribed to the inability to receive trains promptly at terminals. Generally speaking, yard tracks are being used more intensively than any other portion of the railway plant and as a consequence there is practically no reserve capacity for periods of extraordinary traffic or reductions in the effectiveness of the operating forces such as took place in the course of the outlaw switchmen's strike last spring. The amount of money expended for additional yard tracks and sidings has been the largest item in roadway expenditures, and will no doubt continue to absorb a large portion of appropriations. The indications are that, as in the past three years, this money will be devoted largely to minor additions here and there for the purpose of correcting the defects or deficiencies in existing yards, or for the construction of relatively small new terminals. It is interesting to note in this connection that work on only two freight terminals of first magnitude was undertaken during the three past years. In the New Haven's Cedar Hill yard the work is only partially complete, while that on the Illinois Central's Markham yard was suspended soon after starting.

Belt line construction of the nature carried out by the Chicago and North Western at Milwaukee and Chicago in the period just previous to the war has been conspicuous by its absence, and a number of such projects postponed as a consequence of the war must soon come up again for consideration. As a single instance may be mentioned the proposed belt line of the Great Northern around St. Paul. One item of considerable promise is that of flood lighting of new and existing yards as a means of expediting operation, cutting down damage and discouraging pilfering. Yard improvements form an important part of the current budgets.

The terminal problem is often complicated by the bridge problem. The instance of Cincinnati was cited at considerable length by Mr. McAdoo in a statement before the Interstate Commerce Committee of the United States Senate (Jan. 3 and 4, 1919, pp. 32–34):

A concrete illustration will help to emphasize the present difficulties. Cincinnati is an important gateway between the North and the South.

Three important railroads, the Chesapeake & Ohio, the Louisville & Nashville, and the Cincinnati Southern, reach Cincinnati by crossing the Ohio River. Five other important railroads, the Big Four, the Baltimore & Ohio, the old Cincinnati, Hamilton & Dayton, now the Erie, the Pennsylvania, and the Norfolk & Western, reach Cincinnati on the north bank of the Ohio River. The interchange of traffic between these lines at Cincinnati is enormous, and the general public has a vital interest in this interchage being accomplished with the least possible delay and expense. Yet conditions are such that in times of heavy traffic Cincinnati is badly congested with freight and the ability of all the railroads mentioned, not only with respect to handling traffic through Cincinnati, but with respect to handling other important traffic, is largely hampered by the inability to get rid of the traffic which must pass through Cincinnati.

Each of the three railroads approaching Cincinnati from the south has a bridge across the Ohio River. The Cincinnati Southern bridge and the Chesapeake & Ohio bridge are so light that they can not accommodate the heavy locomotives that are used on those roads, so that there must be delay and cost of congestion due to the necessity of changing engines south of the Ohio River on these two roads.

* * * * * * *

It is estimated that there ought to be spent in the near future about $45,000,000 in the rehabilitation of Cincinnati terminals so as to make them equal to modern public needs, with probably $25,000,000 additional for passenger terminals. This involves the building of a new bridge and the reconstruction and enlargement of two other bridges, the construction of convenient and commodious freight houses, the provision of adequate belt lines, and adequate facilities for intercommunication between the different railroads.

During the period of Federal administration the inadequacy of existing terminals was met in very considerable part by consolidating the terminals of competing roads.

The outlook for the continuance of the unified operation of terminals following the return of the roads to private management is not bright. The consensus of opinion seems to be that it is an excellent thing but impossible of realization. While the benefits are numerous, the question resolves itself into the basic human principle that no one individual or corporation cares to create especially desirable facilities which a competitor may use equally as freely on their completion.

Even if consolidation of terminal facilities is effected, there would still remain the need for heavy capital expenditures for this purpose. If the benefits and economies of consolidation are not accomplished, and each road clings to the early policy of completely separate terminals, then the cost of needed improvements will be greatly increased.

The above presentation of authoritative opinions and statistical data makes it evident that the placing of the railroads of the United States in a position to handle all the normal peak traffic, which increases from year to year with the national growth of the country, will require extremely heavy capital expenditures. The exact amount can not be determined with accuracy, but the facts cited indicate that it might well exceed a billion and a half dollars per year for a period of years. This, in time, would mean that the railroads must obtain the necessary funds through stock or bond issues.

The ability of the railroads to borrow on advantageous terms depends upon three principal factors: (1) The earning capacity of the roads, (2) the degree of public confidence in the integrity and efficiency of their operation, and (3) the amount of capital available for investment.

With so many and so complex factors involved, it is impossible to foretell with any accuracy what the future borrowing capacity of the railroads will be. However, from the experience of the past and from conditions now existing, it is possible to form a general judgment as to the future. Such a judgment is rather unfavorable to railroad credit.

For a period of years prior to the war the security flotations of the railways had constantly decreased and the rate of interest paid had steadily advanced. The declining credit of the railroads was reflected in the constantly increasing proportion that bonds constituted of the total security issues. This situation was clearly portrayed in the testimony of Julius Kruttschnitt, of the Southern Pacific Railway, before the Interstate Commerce Commission in 1917 (I. C. C. Docket, Ex Parte 57, vol. 26, p. 11, May 11, 1917):

> Provision for new capital by sale of stock has, within the past 20 years, been impossible in the majority of cases. To what extent funds might have been obtained by taking in new partners or stockholders on a higher level of rates and greater net return is entirely problematical. The fact is that the inability to sell stock has made it necessary to provide additional capital by sale of bonds, with the result that the proportion of bonded debt to capital stock has been constantly increased, with an accompanying decrease in the credit of the borrowing companies. In 1890 the funded debt was but 50 per cent of the total capital obligations of the carriers. In 1916 it has increased to 65 per cent of the total. The result is that the credit of the American railways as a whole is not and has not been good, as indicated by the increased rates of interest which they have to pay and the estimation in which the securities are held by the public as contrasted with the rates of interest at which others can borrow.

Similar statements by other prominent railway officials were frequently made. These officials attributed the condition of the roads to the failure of the Interstate Commerce Commission to sanction higher transportation rates.

The effect of reduced credit on the railroads is shown in the following table, which gives the amount of new capital annually going into the railroads prior to the war:

[From National City Bank Bulletin, December, 1919, pp. 10–11.]

1911	$808,000,000
1912	680,000,000
1913	478,000,000
1914	584,000,000
1915	311,000,000
1916	268,000,000

Mr. W. F. Acworth, a distinguished British railroad economist, in 1916, after a special investigation of the American railroad situa-

tion, also noted the continued failure of the railroads' ability to borrow advantageously. He said on this point:

> Mr. Hill estimated 10 years ago that the railroads ought to spend a billion dollars a year to keep abreast of the public requirements. They have not spent it, not because the expenditure was unnecessary, but because the money was not forthcoming, and somehow you will have to catch up the arrears and take care of the future on an even more generous scale, or the development of the country will be brought to a standstill. * * *
>
> Can the railroads get all the money they need? The question is a very serious one and I will not attempt to answer it. That in the past they have not been able to get out all the long-term bonds they would have liked to sell is sufficiently proven by the volume of short-term notes issued and frequently renewed at maturity. Why should an investor buy railroad bonds? Primarily, he wants security. The fact that over 40,000 miles of railways are to-day in the hands of receivers is sufficient proof that he does not always get it, and if railroads can not sell bonds, still less can they issue common stock. Even the Pennsylvania Railroad, after 70 years of honest and intelligent work in developing the resources of what is perhaps the richest traffic territory in the world, earned in 1914 hardly more net income than sufficed to pay its modest 6 per cent dividend. (The National City Bank Bulletin, July, 1916, pp. 2–3.)

The already unsatisfactory condition of railroad finances was still more adversely affected by the entrance of the United States into the war. Under war-time Federal control the roads were operated primarily for the purposes of war, and financial considerations were subordinated to military purposes. In 1920 the roads were returned to private control, under an entirely new policy laid down by the transportation act—namely that rates should be so adjusted as to yield a 6 per cent return on all property investments. At the same time the Interstate Commerce Commission granted rate increases—varying from 25 to 40 per cent—which were calculated to produce a 6 per cent return.

Almost immediately, however, all calculations were upset by the intervention of a severe business depression which particularly affected railroad traffic. Whether the increased rates were responsible, and if so, to what extent, for the curtailment of traffic is a disputed point. It is, however, an extremely vital point, for if they were responsible the resumption of anything like normal traffic will wait upon a severe reduction of rates. In any case the pressure for a reduction of rates is very strong, and it seems hardly likely that, at best, the railways in the near future will be able or permitted to earn more than the 6 per cent contemplated as a minimum by the transportation act. Whether this will be sufficient to restore their credit is problematical, but in a world in which so much capital has been destroyed by war, the outlook seems very dark for the railroads being able to obtain the money—measured in billions—which they so urgently need.

In connection with the features of the transportation problem discussed above, reference should be made to the excellent series of briefs prepared and published by the Department of Transportation and Communication of the Chamber of Commerce of the United States, summarizing the testimony presented at the hearings on railroad reserves and expenses before the United States Senate Committee on Interstate Commerce in May and June, 1921, by railroad executives, railroad security holders, railroad employees, and railroad shippers and passengers, respectively.

TRANSPORTATION SITUATION IN CANADA.

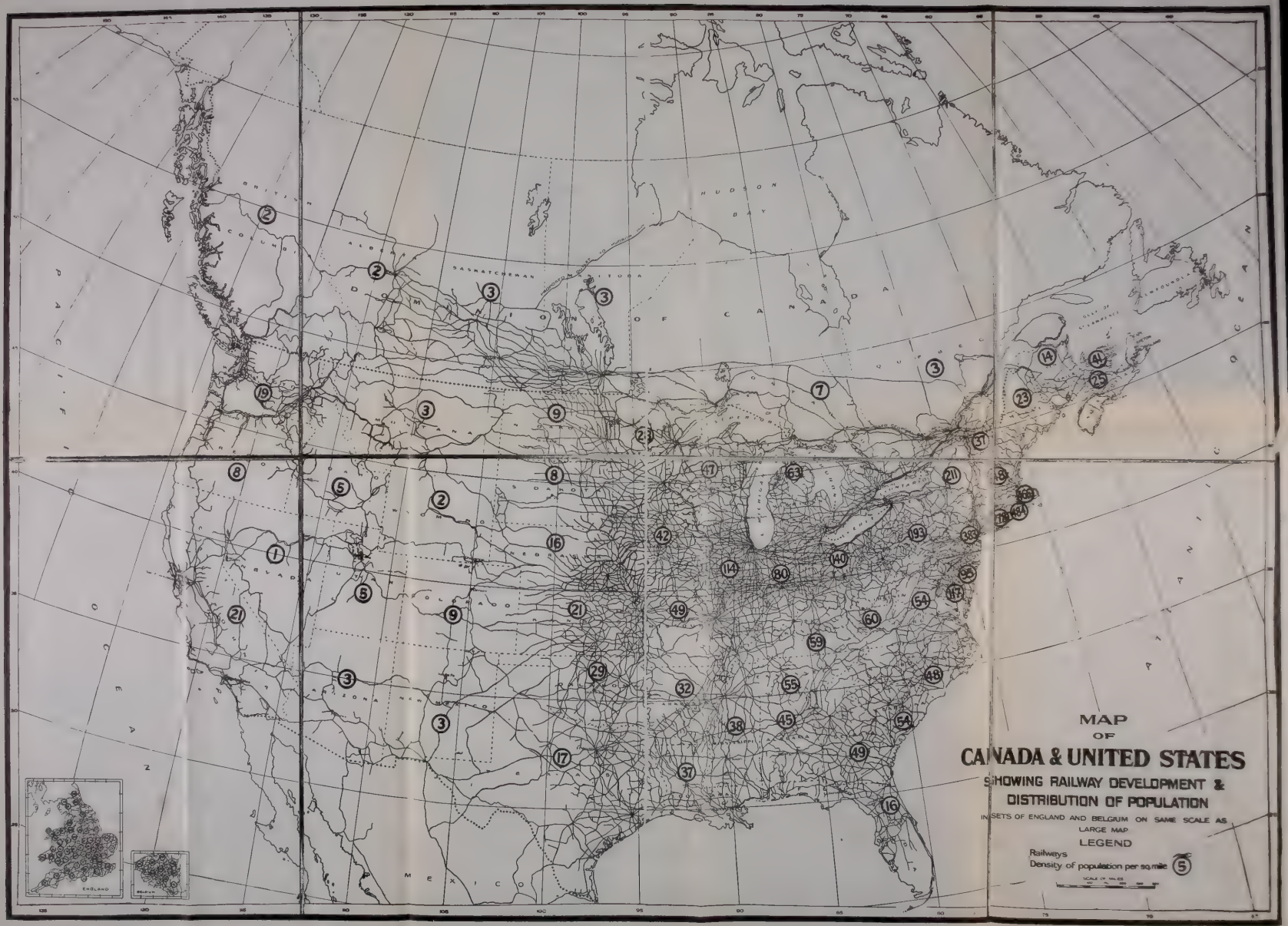
The railway situation in Canada is unusual and demands some explanation. Many years ago a number of small pioneer railways in what are now the Provinces of Ontario and Quebec were consolidated into the Grand Trunk Railway. This system was gradually extended until it covered pretty thoroughly the settled areas of both Provinces. It was an English rather than a Canadian corporation and doubtless suffered through its governing body administering its affairs from London without a proper understanding of local Canadian conditions.

Meantime another railway system, the Intercolonial, was built to connect the maritime Provinces with Quebec and Ontario. This was from the beginning, and is still, a system owned and operated by or on behalf of the Dominion Government. It was built at a time when national rather than commercial considerations were the governing factor, and it has played an important part in the upbuilding of the country.

As the Intercolonial was built to link together the maritime Provinces with the central Provinces of the Dominion, so the Canadian Pacific Railway—a private corporation—was projected to link British Columbia with the east, and was subsidized both in money and land grants. The line ran through an immense territory that at the time it was built was so sparsely populated that many people believed the undertaking must inevitably break down. However, by very skillful management the corporation was steered through the very unprofitable period of early settlement in the Canadian west, and once placed upon a secure footing expanded into an extraordinarily far-reaching and successful transportation system.

Within the last quarter of a century a radical change has taken place in the railway situation in Canada. Previous to the building of the second and third transcontinental lines the commercial needs of the country were reasonably met, though not with complete satisfaction to certain sections of the Dominion, by the existing railways, that is to say, the Intercolonial in the east, the Canadian Pacific and Grand Trunk in the central provinces, and the Canadian Pacific in the west. In 1903, however, the Canadian Parliament decided to build the National Transcontinental line from Moncton to Winnipeg, and at the same time granted a charter to the Grand Trunk Pacific to construct a railway from Winnipeg to the Pacific coast. About the same time the Canadian Northern Railway Co. had linked up a number of scattered lines and assisted by public aid completed a third transcontinental line practically from coast to coast.

This tremendous expansion in railway facilities was the result of the natural optimism of a vigorous and growing and ambitious people. Unquestionably in time the Dominion will need these three transcontinental systems, but the present situation is that railway building has outstripped population and production. Since their completion the second and third transcontinental lines have been constantly in trouble. Repeatedly they were compelled to apply to Parliament for financial assistance, and finally the Canadian people were practically compelled to take over both systems, as well as the Grand Trunk system in eastern Canada. As a result Canada is now responsible for the operation of twenty-two thousand and odd



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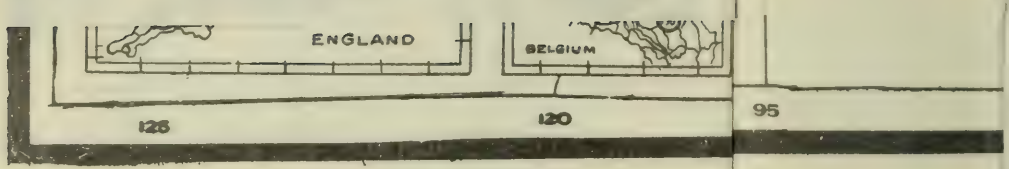

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miles of railway. Although these various lines have been merged in the National Railway system, the consolidation is a process that will take years to perfect. As stated in a recent report, prepared at the instance of the Government of Canada, there are at the present time about 1,800 miles of the National Transcontinental, an equal mileage of the Grand Trunk Pacific, and probably 1,000 miles of the Canadian Northern east of Port Arthur which are not actually needed for the business of the country and will therefore fail for years to earn operating charges.

To recapitulate: Canada now has about 35,000 miles of railway in two great systems, the one, embracing about 40 per cent of the railways, constituting the Canadian Pacific, privately owned and operated, and the other 60 per cent, constituting the Canadian National, directly owned and operated on behalf of the people of Canada. Those who direct the destinies of the National Railway system, although they frankly recognize the seriousness of the problem, state that with public confidence and resourceful leadership the National system will in due course emerge from the present difficult situation. That situation unquestionably is due to the fact that railways in Canada have been developed in advance of the requirements of the country, and the chief remedy will be found "only in increased population, and consequent increased tonnage of commodities for movement by the railways and increased passenger, express, and other revenues. Canada must secure this increase through settlers who will occupy the unoccupied land in the west."

The foregoing will have made clear the essential difference between the existing transportation situation in Canada and in the United States. In the former country railway facilities are in advance of the requirements of the country, while in the latter, at least so far as the area economically tributary to the proposed waterway is concerned, population and production have outstripped railway facilities.

OCEAN TERMINAL CHARGES.

Another feature of the transportation problem which must be alluded to and which is dealt with at considerable length in the McElwee-Ritter brief is that of the costs of terminals in the ports of the Atlantic seaboard.

In consequence of frequent statements of the proponents of the St. Lawrence waterway that the terminal charges in these ports were excessive and that a saving would be involved by the use of the St. Lawrence route, the commission has had the statements of Messrs. McElwee and Ritter checked by an expert statistician and that gentleman has brought together a certain amount of additional information. The data from both sources are to be found in Appendix A and Appendix B2. These appendices cover the costs of lighterage, freight transfer in the ports, pilotage, wharfage, towage, stevedoring, and other incidental costs of port borne by the importer or shipper or vessel owner, in great minuteness of detail. Some of the years for which these data were gathered were abnormal years, but nevertheless the information has a bearing on the St. Lawrence route and the routes via Atlantic ports, and the commission feels warranted in including it in the appendices.

PART V.

WATER POWER PROBLEM.

So far as the water power problem is concerned, the evidence secured at the hearings was very meager, and for the most part was merely incidental to the transportation problem. Those who favored the development of power on the St. Lawrence argued that it could be produced so cheaply that it would not only command a ready sale but would also carry a large percentage of the cost of the combined undertakings; that it would be linked up with the proposed superpower scheme on the Atlantic coast, and probably with the hydroelectric system in Ontario; that it would conserve the coal supplies, and relieve the railways of the burden of carrying millions of tons of coal; that markets would be available for all the power that could be developed on the St. Lawrence, particularly in view of the long distances to which power could be to-day economically transmitted; that it would be utilized to an increasing extent in the electrification of the railways; that the banks of the St. Lawrence, with cheap power and cheap water transportation for the carriage of both raw materials and finished products, must inevitably become the scene of an enormous industrial development, particularly in the big basic industries.

Those who opposed the development of water power on the St. Lawrence argued that the cost of development would be prohibitive; that there was no market for it in eastern Ontario or the Montreal district, which were already supplied from other sources; that other available water powers in the State of New York, and on the Ottawa, St. Maurice, and other rivers in Canada, could be more economically developed than those of the St. Lawrence. Unfortunately those who spoke, both for and against the project, confined themselves for the most part to expressions of opinion, and very little real testimony was put before the commission upon which it could base a reasoned judgment.

A representative statement on the part of those who favored the development of power on the upper St. Lawrence was that of Col. John H. Finney, electrical engineer, at the preliminary Buffalo hearing. "I believe," he said, "that the water power of the St. Lawrence is of infinitely more value to commerce than any navigation which will use the streams after they have been improved for navigation. But fortunately there is no conflict between the two because any proper development of the St. Lawrence for power will at the same time take care of the navigation features." He held that the value of this power would be sufficient to carry the cost of the entire undertaking, both navigation and power. There was no

question as to the possibility of marketing, as all the available power on the St. Lawrence could be readily absorbed by growing industries.

Col. Finney described the projected superpower line, a high tension transmission line designed to serve the Atlantic seaboard from Maine to Virginia. This district, which he believed would always be the workshop of the United States, absorbed a great deal of power to-day, and its demands were increasing at a tremendous rate, not only for industry and lighting, but also for the electrification of the railroads. Into this superpower line would be fed at various points power generated at every available water site, as well as at various coal mines in both the soft coal and anthracite regions. It would be a 250,000-volt line that could carry on a single circuit, perhaps 400,000 horsepower, and at a cost that would make it commercially profitable. That meant that power in every available stream within a radius of from 250 to 400 miles would be finally put in service by linking it up with this trunk line. The powers of southern streams, such as the Potomac, the Susquehanna, and the Delaware, would be brought into the system, as well as the large group of powers in New York State, power from Niagara Falls, and power generated on the St. Lawrence. Col. Finney anticipated that, as St. Lawrence power on the American side would be linked up with the superpower line on the Canadian side, it would probably be absorbed very largely by the hydroelectric system of Ontario. This, of course, would apply only to power developed west of the Quebec boundary.

In regard to the practicability of transmitting power economically for long distances, he cited Mr. Pearce Thomas, an eminent high-transmission engineer of the United States, to the effect that on the proposed superpower line the total loss would only amount to about 5 per cent. This made it quite practicable to link up both St. Lawrence and Niagara power with the superpower line.[1]

Col. Finney was very emphatic as to the extent of the demand for power in the United States. "Some of the younger men in this room," he said, "will probably live to see the time when every foot of falling water capable of commercial development will be developed. * * * There is no question about the fact that the Nation is short of power;" and he added elsewhere, "We will develop power as the Nation needs it as long as we have any sort of power, and that is coal and oil and water and perhaps denatured alcohol." He pointed out that so far as the United States was concerned there was a tremendous amount of water power on the Pacific coast where the industrial demand was not yet very considerable; there was very little power in the Middle West where fortunately the demands were also slight; but on the Atlantic coast there was the greatest demand for power and the smallest amount of water power. Most of it at present was steam-generated power, and that involved a tremendous tax on the transportation system of the East to bring in coal.

In regard to the electrification of the railroads, this would mean an increase of several million horsepower, and yet he believed that it must come because of the tremendous advantages to the railroads

[1] For fuller details of the superpower line project, reference may be made to the Report on a Superpower System for the Region between Boston and Washington, by W. S. Murray and others, Washington, 1921. U. S. Geol. Survey Professional Paper 123.

and to the country. It meant saving about two-thirds of the coal consumption, as well as a very considerable saving in transportation facilities.

Some interesting testimony was also submitted to the commission by William L. Murray, chairman of the superpower survey. He pointed out that the principal object of that scheme was the conservation of power. Every time a freight locomotive went in operation, for every 5 tons of coal it burned it wasted 3 tons. The actual coal waste due to an improper form of power production and distribution amounted to 30,000,000 tons annually, in a territory extending for about 150 miles. That immense tonnage of coal had to be transported on the railways, and it had to come from the mines, a distance of anywhere from 200 to 250 miles.

The purpose of the superpower survey was to determine the allocation of the amount of waste due to an improper form of power production and distribution, and to recommend a regional plan through the means of which this waste would be eliminated. It was an interesting fact that the steam locomotive handling a freight train with equal weight on the drivers consumed on an average two and a half times as much coal as an electric engine; in other words, it took two and a half times as much coal to produce the same power and speed. The contrast was even more marked in the case of a switching engine.

In the superpower scheme all the available power would be brought together into a common system and distributed to the industries and to the railways, thereby increasing the load factor from 10 to 50 per cent, as compared with steam power.

In regard to the St. Lawrence power and its advantages in furthering the economic welfare of the State of New York, he pointed out that it was now possible to transmit 500,000 horsepower 300 miles at a loss of about 6 per cent. Put that power down into any industrial zone and it would mean that you would eliminate the shipment of 3,000,000 tons of coal per annum. That was a tremendously important consideration in New England. It must be remembered that power was the father of all movement; that power in the form of coal was maximum in bulk and minimum in efficiency; that power in the form of electricity was minimum in bulk and maximum in efficiency.

In the development of water power on the St. Lawrence, the value of that power to a company or corporation developing it and selling it at that point would be somewhere between $25,000,000 and $30,000,000 a year for somewhere between 750,000 and 1,000,000 horsepower. That would be at the rate of about $26 per horsepower, when all the power was utilized.

Ontario's interest in the development of power on the St. Lawrence was expressed by Sir Adam Beck in a memorandum on behalf of the Hydro-Electric Power Commission of that Province. The general policy of this commission was, he said, to complete first the development of all available power at Niagara; then to join the Federal Governments of Canada and the United States in the development of the international water powers on the St. Lawrence; and, finally, to develop the water powers on the Ottawa River. The intention was to link up these great main sources of power by means

of an interconnected transmission network which would embrace also such of the smaller water powers as could advantageously be included in the main scheme. In other words, the Hydro-Electric Power Commission had in contemplation a project very much along the same lines as the proposed superpower line on the Atlantic coast.

In regard to the probable market for Niagara power in Canada, Sir Adam pointed out that when the Chippewa project had been put in operation 56 per cent of the total available water at Niagara would have been absorbed, leaving only 44 per cent for future needs. He explained that the scenic argument was not the only one limiting the amount of water that could be diverted at Niagara. A more compelling reason was the fact that a sufficient volume of free flow must be maintained in the river to dispose of the immense quantities of ice frequently driven down Lake Erie by spring gales. As a matter of fact, apart from any limitation because of scenic effect, there was only about 100,000 second-feet of water available for both countries for power purposes at Niagara, and even this was contingent on the regulation of Lake Erie.

In view of the constantly increasing use of hydroelectric power for domestic and industrial purposes, Sir Adam Beck thought it not unreasonable to predict that the next decade might see the power possibilities of Niagara completely exhausted. It was therefore very necessary that Canada and the United States should make provision for developing the immense latent power resources of the St. Lawrence, and their plans should be formulated without delay if a serious check to industrial development was to be avoided.

On behalf of those interests that questioned the desirability of developing water power on the Upper St. Lawrence, Mr. R. M. Wilson, chief engineer of the Montreal Light, Heat & Power Co., argued that there was no prospect of a market for this power on the Canadian side, at any rate so far as the Montreal district was concerned. It was estimated that the increasing demand for hydroelectric power in that district amounted to about 10,000 horsepower per annum, and the existing agencies had already made provision to take care of this development for the next 10 years. It was anticipated that at the end of that period the total demand would amount to about 400,000 horsepower. That would be sufficient to take care, among other things, of the electrification of the railways in and around Montreal. All this power could be supplied from power sites that were already under development.

Mr. Wilson was of the opinion that, because of the low head, it would be impossible to develop power on the St. Lawrence at a price that could compete with power from the St. Maurice. There was enough undeveloped power in the St. Maurice to supply Montreal district for 30 or 40 years. St. Lawrence power under present-day conditions would, he believed, cost from $300 to $325 per horsepower development, whereas on the St. Maurice you could get it for from $80 to $100. As a matter of fact the days of cheap water power were gone. Greater efficiency had been secured, but the cost of apparatus and labor had gone up enormously.

Other witnesses, in discussing the possible market for St. Lawrence power on the Canadian side, emphasized the fact that there was still more than sufficient undeveloped power in the Ottawa River to supply all the requirements of eastern Ontario.

On the United States side, criticism of the proposed development of power from the St. Lawrence was confined largely to the State of New York, the State Commission in Opposition to the St. Lawrence Ship Channel, and other organizations and individuals, arguing that other and more central power sites in the State made it unnecessary at the present time to develop power from the St. Lawrence. The State commission filed a report of the Conservation Commission of New York on the water power resources of the State, from which it appears that the total power available in the State amounts to 2,926,470 horsepower, of which 981,517 is classed as power available with present installation and present flow, and 1,944,953 as undeveloped power. These totals include power from the Niagara and the St. Lawrence, as well as from the barge canal.

Since the hearings a letter has been filed with the commission from Mr. Paul T. Brady, of the Westinghouse Electric & Manufacturing Co., who discusses the probable markets for St. Lawrence power in New York and New England. He quotes Mr. W. Barclay Parsons to the effect that the metropolitan district of New York would need before 1930 a generating capacity of at least 2,000,000 kilowatts, which would mean an investment of at least $200,000,000. Mr. Brady had no doubt that before St. Lawrence power would be available there would be a market in the metropolitan district of New York for at least 1,000,000 kilowatts from the St. Lawrence, which would be equivalent to a saving of 8,000,000 tons of coal, or, at the present cost of coal, $48,000,000. He was also of the opinion that 500,000 kilowatts would readily be absorbed in New England industries, and this total of 1,500,000 kilowatts would represent a saving in coal consumption of $80,000,000.

Mr. Brady made the point that it was very difficult for the railroads to-day to find money for improvements, additions, and betterments; that therefore it was doubly necessary for them to conserve their resources, and that as hydroelectric developments were going to be the most favored lines of securities it would be much easier to secure money to develop power on the St. Lawrence than to obtain a like amount for railway improvements.

As to the cost of developing power on the St. Lawrence and the probability of markets on both sides of the boundary, the commission had secured since the date of the hearings certain additional data, which is briefly summarized in the following pages.

These data are contained in a special report by the Water Power Branch of the Department of the Interior of Canada, in the recently published report of W. S. Murray and others on a superpower system for the region between Boston and Washington; in a communication received from the Director of the United States Geological Survey; and in the report of the Hydro-Electric Power Commission of Ontario attached to this report.

The Dominion Water Power Branch discusses the power situation in that portion of Canada which is particularly interested in the development of the St. Lawrence, and deals with the available water powers developed and undeveloped within a radius of 300 miles of the Long Sault site, as well as with the expected future growth of water power development. Attention is drawn to the fact that the St. Lawrence River will probably have to be called upon

to meet the power needs of a large area in Eastern Ontario and Western Quebec.

Indications as to future growth are particularly emphasized, the probable development in Canada to be reached by 1940 being given as 3,900,000 horse-power in the area within the 300-mile radius. As regards the available water powers within this area, it is pointed out that "while it may be possible for a few years to cover Canada's power needs from sources other than the St. Lawrence River, it is only a matter of time when the potential possibilities of this great international artery will be of pressing importance to the Dominion."

Concrete facts and figures on the general power situation are presented, mainly by means of the accompanying table and graphs.

Graph No. 1 shows the location, and Table No. 2 the principal features, of the existing water-power installations on the St. Lawrence River and certain tributaries. With regard to the more important developements thus covered it will be seen that the section of the main river lying wholly in Canada contains the larger portion. The most important hydroelectric plant is that of the Montreal Light, Heat & Power Consolidated at Cedars, operating under a head of 30 feet, with twelve units aggregating 129,600 horsepower, and two additional units of 10,800 horsepower each now being installed. In the same vicinity the same company operates the Soulanges plant which has a capacity of 16,500 horsepower in three units under a head of 50 feet. On the other side of the river, opposite these two plants, at St. Timothee, the Canadian Light & Power Co., (Ltd.), has 30,400 horsepower divided into four units operating under a head of 50 feet. At Valleyfield a total of 9,345 horsepower is used mainly by the Montreal Cottons Co. under heads of from 8 to 10 feet. At Lachine Rapids the Montreal Light, Heat & Power Consolidated has another plant of 15,800 horsepower under a head of 14 feet, while additional water power is supplied by the latter rapids to smaller industries along the Lachine Canal aggregating some 5,000 horsepower.

In the international section of the river the principal plants on the Canadian side are the St. Lawrence Power Co., (Ltd.), at Mille Roches, Ontario, with an installation of 2,600 horsepower; the Beach hydroelectric plant at Iroquois with 500 horsepower; the Morrisburg hydroelectric plant of 1,000 horsepower, which is not in operation; the Howard Smith Paper Mills, (Ltd.), at Cornwall with 800 horsepower and 4,500 horsepower being installed at the latter town for the Canadian Cottons, (Ltd.) In addition to the above there are a number of smaller water-power installations on the Canadian side of this section of the river. On the United States side the Massena, N. Y., plant of the St. Lawrence River Power Co. has an installation of 86,000 horsepower under a head of 42 feet, while the New York & Ontario Power Co. has a 600-horsepower plant under a head of 9 feet, at Waddington, N. Y.

Graph No. 2 depicts the available and developed water powers of Canada located within 300 miles of the Long Sault. The available power is given as 24-hour power at 80 per cent efficiency dependable for at least six months each year irrespective of betterments from storage The table shows that, assuming complete development at

Niagara Falls, the total undeveloped water power at the 464 sites located within the area considered aggregates 9,348,269 horsepower, of which the St. Lawrence River is responsible for 3,270,842 horsepower, divided as follows:

	Horsepower.
Long Sault site (Canadian half)	878,680
Lake St. Francis-Lake St. Louis site	1,564,725
Lachine Rapids site	827,437
Total	3,270,842

The total undeveloped water power in the area may be divided as to capacity of individual sites in the following manner: It comprises 10 sites each of 100,000 horsepower and over, aggregating 6,618,176 horsepower; 16 sites between 50,000 and 100,000 horsepower, aggregating 1,068,075 horsepower; 14 sites between 25,000 and 50,000 horsepower, aggregating 511,320 horsepower; 68 sites between 5,000 and 25,000 horsepower, aggregating 677,576 horsepower; and 356 sites under 5,000 horsepower, aggregating 473,122 horsepower.

The developed water power within the 300-mile circle totals 914 plants, with an installed turbine capacity of 1,913,084 horsepower, including the two units already installed at the Queenston development, while it is noted that three additional units of 60,000 horsepower will be installed at the latter plant in 1922.

Graph No. 3 shows the growth in the use of water power within the area considered and provides the means of predicting future growth. It is pointed out that the assumption of the same rate of growth in the future as was found in the past is a conservative one, owing to the additional possibilities from the electrification of railways and the anticipated development of electrochemical industries.

The curve shows a water-power development within the area as follows:

	Horsepower.		Horsepower.
1905	330,000	1925	2,350,000
1910	720,000	1930	2,875,000
1915	1,420,000	1935	3,405,000
1919	1,655,000	1940	3,935,000
1921	1,913,084		

Graph No. 4 shows the electric transmission systems within the area considered and the tabular statement indicates the status at the beginning of 1920. Bringing the Canadian figures up to date the installed primary power now serving the principal transmission systems in southern Ontario totals to 781,300 horsepower, and in Quebec to 675,915 horsepower, totaling for the two provinces 1,457,215 horsepower. From this figure there should be deducted 223,000 installed horsepower to meet demands of power exported to the United States (143,003 horsepower years were exported in the year ending March 31, 1920) leaving a net total of 1,234,215 horsepower. It is further pointed out in this connection that the St. Lawrence River powers bridge the gap between the Quebec and Ontario systems and provide an enormous surplus of energy to feed a future trunk line transmission system paralleling the St. Lawrence from Windsor to the mouth of the Saguenay River. With the power available on the St. Lawrence added to the available surplus on the Niagara, Ottawa, St. Maurice, and Saguenay Rivers, together with lesser power rivers,

there is available in eastern Canada practically 10,000,000 hydro horsepower.

The Director of the United States Geological Survey has furnished for the information of the commission the accompanying diagram of curves (Graph No. 5) showing the past growth and probable future demand for power in the State of New York and in the New England States, which is practically equivalent to the 300-mile area on the Canadian side referred to in the preceding paragraphs. These curves represent the installed prime mover capacity in manufactures, central stations, and electric railways in the above States, based on actual census figures from 1900 to 1919 and extended to 1930 at the probable rate thus indicated.

The following figures on past and future growth have been extracted from the curves. They represent total primary power installation:

	Horsepower.		Horsepower.
1900	3,700,000	1919	9,300,000
1905	5,000,000	1921	9,900,000
1910	6,600,000	1925	11,000,000
1915	8,100,000	1930	12,500,000

In connection with the probable demand indicated above, the Director of the Geological Survey is of opinion that "It indicates without question that the demand for power in New York and New England would take care of all the power that might be developed on the St. Lawrence as soon as it was made available for utilization." He points out that this opinion is confirmed by the statement in the report on the superpower survey to the effect that St. Lawrence power under present construction and operating costs can be placed in central New York and Massachusetts for 4.6 mills per kilowatt-hour and at Paterson, N. J., for 5.7 mills per kilowatt-hour. He adds, "If we compare these costs with 19.3 mills per kilowatt-hour, the production cost of electric power by public-utility plants in the superpower zone in 1919, there should be no doubt in anyone's mind that there would be sufficient demand for all the power that can be made available on the St. Lawrence."

The results of the superpower survey are given in a very comprehensive report compiled by eminent engineers under the chairmanship of W. S. Murray, and published by the United States Geological Survey. This report throws much light on the question of possible markets for St. Lawrence power in the United States. The primary object of the survey was to obtain a more efficient production and distribution of power in that portion of the country where industrial and other demands were most marked. The recommendations in the report propose to attain this object by (1) replacing small plants by fewer but larger ones; (2) an interconnection of transmission systems or superpower plants, resulting in the supply of a greater amount of noncoincident demands from the same generating station capacity; (3) maximum economic utilization of available water power. The territory covered, called the "superpower zone," is described as lying between the thirty-ninth parallel (near Washington, D. C.) and the forty-fourth parallel (22 miles north of Portland, Me.) and extends from the coast approximately 150 miles inland. The ultimate aim is to be reached by gradual steps and the data in the present report cover primarily conditions up to

1930. However, further estimates or predictions extend beyond this date in certain cases, as for instance, the utilization of the power of the St. Lawrence and Niagara by the system projected for 1932.

In connection with the power demand in the zone, W. S. Murray explains that the market for superpower energy will be furnished by the electric utilities, the industries, and the railroads, the estimated requirements in 1930 being some 31,000,000,000 kilowatt-hours, and in replacing independent operation an annual saving of $339,000,000 could be effected by the proposed coordinated power system. The future requirements are based on the increases during the past 10 years projected at a somewhat lower rate to the year 1930. The future estimates are therefore conservative.

In an appendix to the superpower report are included further details of the estimated demand which is given as 4,854,000 kilowatts (6,500,000 horsepower) in 1919, 5,602,000 kilowatts (7,520,000 horsepower) in 1925, and 7,422,000 kilowatts (9,950,000 horsepower) in 1930, the latter representing an energy consumption of 30,712,000,000 kilowatt-hours. A graphic representation shows that this consumption would be divided approximately 68.4 per cent for industrial and domestic use, 15.3 per cent for electric railways, and 16.3 per cent for electrified heavy traction railroads.

To meet this estimated future demand it is intended to retain a portion of the existing plants while the new power plant capacity required in the zone by 1930 would be 4,980,000 kilowatts (6,680,000 horsepower). In 1930 the total hydroelectric capacity installed within the zone would be 1,501,500 kilowatts (2,013,000 horsepower), representing a total investment of $245,977,000.

With regard to the development of hydroelectric energy within the superpower zone, the principle that this kind of development is economically justified if it produces power at a cost less than that of a steam-electric plant of the same capacity is emphasized and the hydroelectric energy thus available within the zone will amount to less than 21 per cent of the total electric power required in 1930. Water-power resources below 5,000 kilowatt (6,700 horsepower) have been disregarded in the studies and those considered economical for the system are, Potomac River, 200,000 kilowatts (268,000 horsepower); Susquehanna River, 185,000 kilowatts (248,000 horsepower); Delaware River, 350,000 kilowatts (469,000 horsepower); Hudson River, 150,000 kilowatts (201,000 horsepower); Connecticut River, 165,000 kilowatts (221,000 horsepower), or a total of 1,050,000 kilowatts (1,407,000 horsepower).

The anticipated expansion of the public-utility load is shown by an increase from 10,000,000,000 kilowatt hours in 1919 to 26,000,000,000 kilowatt hours in 1930; this allows a safe annual growth of 9 per cent for the future as against 11 per cent which has taken place during the past 10 years. The present importance of electric supply is shown in the report by a list of over 1,500 electric-power organizations engaged in public service in the States in which the superpower zone is situated.

With regard to the electrification of railways, the zone contains 36,000 miles of railroads, of which 19,000 miles could be profitably electrified. The total energy required in this connection would be 4,423,300,000 kilowatt hours per year and a load factor of from 50

to 53 per cent is given as the average for unified operation. The coal saved annually through this electrification would be 8,890,200 tons.

In connection with the industrial field the analysis of the power taken by all the industries in the zone shows that the majority produce their own power and this mainly from coal. It further shows that in 1919 the maximum economical use of purchased power (electric motors replacing private prime movers) would have saved 13,502,100 tons of coal. In that year the industrial power supply equipment in the zone had an aggregate capacity of 9,069,471 horsepower, of which 5,426,929 horsepower was steam, 541,033 horsepower hydraulic, 279,040 horsepower internal combustion, 2,822,469 horsepower for purchased energy such as supplied electric motors. The industries requiring the greatest capacities were cotton goods, 895,513 horsepower; woolen goods, 380,229 horsepower; steel works and rolling mills, 571,666 horsepower; iron and steel products not classified, 919,150 horsepower; paper and wood pulp, 482,086 horsepower; unclassified chemicals, 289,867 horsepower; nonferrous metals, 297,209 horsepower; anthracite mines, 899,726 horsepower.

The industrial analysis does not include the waterworks in the zone, but these, it is estimated, would require 340,000,000 kilowatt hours of energy.

The predicted industrial power requirements for 1930 are obtained by a curve of previous rate of increase prolonged into the future, and shows a required capacity of 12,000,000 horsepower by 1930.

The power production cost of electric utilities in the superpower zone in 1919 was $54.30 per kilowatt-year ($40.50 per horsepower-year) for steam-electric plants, and $34.70 per kilowatt-year ($25.90 per horsepower-year) for hydroelectric plants.

The unit cost of power delivered at load centers in 1930 is estimated at $43.80 per kilowatt-year ($32.70 per horsepower-year). In the anthracite division, base-load steam-electric plants are estimated to produce electric energy in 1930 at 5.7 mills per kilowatt-hour, based on an annual capacity factor of 75 per cent, or the same basis, at approximately $38.30 per kilowatt-year ($28.60 per horsepower-year) of effective capacity.

The combined use of steam and water power is estimated to yield annually $69,550,000 on an increased investment of only $44,838,000, this being obtained through the highest economy in steam-produced power, together with the maximum use of water power.

The new hydroelectric plants for the superpower system are to be located only at the most economical sites and the unit investment cost is estimated at $151.30 per kilowatt ($112.80 per horsepower) of installed capacity, while for the retained hydroelectric plants the investment is given as $193.60 per kilowatt ($144.50 per horsepower).

In particular regard to the electrification of 19,000 miles of railroads, it was estimated that this could be accomplished at a total expenditure of $570,000,000, effecting an annual saving of $81,000,000 or 14.2 per cent on investment. As this expenditure was based on costs in 1919, it is pointed out that it would probably be reduced to not more than $400,000,000 by 1926.

The absorption of the power from the St. Lawrence and Niagara into the superpower system is set for 1932. It is assumed that it will take eight years to construct the St. Lawrence hydroelectric

works and, owing to treaty restrictions, the same length of time to have Niagara power available for the superpower zone. If these developments were completed by 1930 the load growth in certain divisions of the zone should be sufficient by 1932 to absorb their available output, namely, 300,000 kilowatt (402,000 horsepower) from Niagara and 600,000 kilowatt (804,000 horsepower) from the St. Lawrence. The former would be for the metropolitan (New York) division while the St. Lawrence power would be for the northern portion of the zone.

The estimates on the available power from the St. Lawrence are based on the development of a head of 80 feet at the Long Sault, with an installed capacity of about 1,200,000 kilowatt (1,610,000 horsepower), yielding an annual output of more than 10,000,000,000 kilowatt-hours, one-half of this output to be allocated to the United States. No estimates are attempted as to the cost of development, but it is assumed that this should be lower per unit than that of any of the developments on which estimates are given in the superpower report on account of the size of the development and because a large portion of the expenditure would be made for the improvement of navigation. The report further remarks that the additional Niagara power, if available, would probably be cheaper to develop than the St. Lawrence power. However, in the economic estimates contemplating their utilization, the cost of power from these two large sources is assumed at not over $20 horsepower-year at the plant bus bars.

With regard to the saving which these two sources would mean to the superpower system, it is calculated that while the annual cost of the St. Lawrence power delivered at load centers would be $130,273,000, the same amount of energy from new steam plants would cost $141,601,000, the St. Lawrence power thus effecting a saving of $11,328,000 a year. In the same manner, the block of power from Niagara would cost $107,651,000 annually, while the same amount supplied from steam would cost $110,899,000, showing a saving of $3,248,000 a year.

The coal saved annually in the superpower zone by using the available energy from these two large developments as suggested is estimated at 2,234,000 tons for the St. Lawrence and at 1,204,000 tons for Niagara.

The feasibility of transmitting electric energy over the required long distances is fully discussed in the report, and in this connection the performance of the proposed transmission line from the St. Lawrence River to a point in central New England is shown graphically and various items of interest presented in tabular form. The proposed line would be 225 miles long, operating at 220,000 volts and designed to transmit 300,000 kilowatt (402,000 horsepower) under normal conditions and double this amount in an emergency. This transmission system comprises two tower lines, each supporting two circuits.[1]

Some of the items given in the tabular statement in the report have been extracted and presented here in Table No. 1.

[1] This line evidently is meant to carry only one half of the 600,000 kilowatts available from the St. Lawrence for the superpower system in the United States, the other half being transmitted to two other points over other lines.

TABLE No. I.—*Character and performance of transmission lines.*

Character and performance.	St. Lawrence-New England line.[1]	Niagara-New York line.	Pittston-Newark line.[2]
Energy to be transmitted (kilowatts)	300,000	300,000	300,000
Length of line (miles)	225	350	115
Voltage at generating end	220,000	220,000	230,000
Number of tower lines	2	2	2
Number of circuits per tower line	2	2	1
Line losses (kilowatts)	12,500	28,500	13,800
Transformer losses (kilowatts)	10,500	10,500	10,500
Synchronous-condenser losses (kilowatts)	5,600	7,200	6,400
Total losses (kilowatts)	28,600	46,200	30,700
Efficiency of transmission (per cent)	91.3	86.7	90.7

[1] This line evidently is meant to carry only one-half of the 600,000 kilowatts available from the St. Lawrence for the superpower system in the United States, the other half being transmitted to two other points over other lines.
[2] Line from steam-electric sources.

In the report of the Hydro-Electric Power Commission of Ontario a good deal of attention was devoted both to the question of possible markets and the cost of development. While the estimates of future demands may seem large, attention is drawn in the report to the experience of the Hydro-Electric Power Commission whose initial contract for 100,000 horsepower was criticised at the time as ill-advised, but nevertheless within five years the whole 100,000 horsepower had been marketed. The Queenston-Chippewa development with 550,000 horsepower ultimate capacity is referred to as an example of the confidence of the hydroelectric commission in the extent of future markets which from past experience have been found to materialize in a manner which has more than justified the decisions arrived at.

The extensive growth of the operations of the hydroelectric commission is shown by means of a table from which the following is an extract:

Year.	Total consumers.	Total load in Ontario only.
		Horsepower.
1910		750
1915	120,828	103,959
1919	215,086	262,281
1921	265,000	305,247

The future growth in demand is based on the per capita consumption—at present this is 900 kilowatt-hours per annum based on a territory with a population of 2,900,000. It is expected that the annual per capita consumption will soon reach 1,200 kilowatt-hours and by 1941 is expected to be 1,500 kilowatt-hours. Based on these and the corresponding increase in population, the future demand in Ontario is given as:

	Horsepower.
1931	932,000
1941	1,340,000

The above estimate does not allow for possible railway electrification or specialized new industries.

Regarding the possible markets for the St. Lawrence power in Ontario, the area within a radius of 200 miles is taken and, based on the annual per capita consumption of only 900 kilowatt-hours for 1931 and 1,200 kilowatt-hours for 1941, the following future demands are estimated for this portion of Ontario:

	Horsepower.
1931	121,000
1941	190,000

A similar estimate, based on per capita consumption, is given for the United States side within a radius of 300 miles from Cornwall with the following results:

	Horsepower.
1931	5,600,000
1941	8,600,000

The combined future demand in Ontario, within 200-mile radius, and the United States, within 300-mile radius, is then given as follows:

	Horsepower.
1931	5,720,000
1941	8,790,000

In this connection it is pointed out that the power commission has not considered lower St. Lawrence powers, as it may be found best to develop the international portion first in order that the United States may, as soon as possible, have her equity for her own needy markets. It will be noted also that the hydroelectric commission confines its attention, so far as Canadian markets are concerned, to the Province of Ontario.

The report also calls attention to additional special markets, such as railway electrification, for which the following possibilities are suggested:

	Horsepower.
1931	30,000
1941	100,000

The exportation of electricity from the Canadian side is also taken up as a possible market, but under the assumption, first, that the exportation of electrical energy in large quantities shall only be permitted under strict governmental control as under the Canadian electricity and fluid exportation act; second, that the operations be conducted upon a sound economical basis; and, third, that full, proper, and workable provision be made for the progressive reclamation of all exported power as and when the need arises for its use in Canada. In this connection quotations and instances are given proving that there is a demand for more power on the United States side.

The total undeveloped power of the St. Lawrence in the three power reaches between Prescott and Montreal is given as 4,000,000 horsepower, of which five-twelfths, or 1,665,000 horsepower is in the upper reach. The total already developed is 300,000 horsepower, of which 200,000 horsepower is on the Canadian side and new equipment will increase the Canadian capacity by 60,000 horsepower.

The respective costs of the three schemes proposed in the international section are given, with a due proportion charged to navigation. Scheme A is for a single-head development, B and C for two-stage development.

The following is extracted from the table showing estimated costs:

	Continuous capacity (horsepower).	Capital cost charged to power (horsepower).
Scheme A complete	1,492,000	$95
Scheme B complete	1,600,000	96
Scheme C complete	1,635,000	95

The cost per horsepower-year in connection with the above capital costs is given as from $23 to $30 for a block of 400,000 horsepower supplied at the other end of a transmission line 300 miles long.

In comparison with this, the cost of steam-electric energy in New York is given as $60 per horsepower-year.

It is calculated that the total power of the St. Lawrence in the international reach would save 80,000,000 tons of coal in 60 years if used as secondary power to steam central stations in the United States and would save 34,000,000 tons per year as primary power or a total saving of 35,500,000 tons per annum.[1]

TABLE No. 2.—*Installed turbine capacity.*

Plan No.	Index No.	Name of owner.	Location.	Head in feet.	Turbines installed.		Remarks.
					Number of units.	Horsepower.	
		ALONG ST. LAWRENCE RIVER IN CANADA.					
1	$2MB_6$	Canada Starch Co. (Ltd.)	Cardinal, Ontario	6	.....	280	
2	$2MB_1$	Beach Hydro-Electric System.	Iroquois, Ontario	12	2	500	
3	$2MB_2$	Town of Iroquois	do	12	3	287	
4	$2MC_8$	Town of Morrisburg	Morrisburg, Ontario	10	4	1,000	Not in operation.
5	$2MC_9$	do	do	9	1	250	
6	$2MC_2$	St. Lawrence Power Co. (Ltd.).	Mille Roches, Ontario.	25	2	2,600	
7	$2MC_{25}$	Town of Cornwall	Cornwall, Ontario	18	2	350	
8	$2MC_{11}$	Toronto Paper Manufacturing Co.					
		New Howard Smith Paper Mills (Ltd.).	Cornwall, Ontario	8	13	800	
9	$2MC_{27}$	Canadian Cottons (Ltd.)	do	24	3	4,500	Being installed.
10	$2MC_1$	Cornwall Street Railway Light & Power Co. (Ltd.).	do	12	2	400	
11	$2MC_{10}$	Stormont Electric Light & Power Co. (Ltd.).	do	15	2	130	Auxiliary to purchased power.
12	$2MC_{12}$	Canadian Cottons (Ltd.)	do	22	1	.....	Stormont Mill.[a]
13	$2MC_{13}$	do	do	20	3	.....	Canada Mill.[a]
14	$2MC_{14}$	do	do	20	1	.....	Dundas Mill.[a]

[a] To be absorbed by No. 9.

[1] The following explanation of electrical terms or units may be desirable: Kilowatt (k. w.) and horsepower (h. p.) are units of the same dimensions and are easily converted from one to the other, 1 horsepower being approximately equivalent to three-quarters of a kilowatt. Each of these is an instantaneous measure of power or rate of doing work. The kilowatt-hour (k. w. h.) unit is a measure of energy with the time element considered or, in other words, involving the period of time during which work is performed or energy consumed. To be able to compare the kilowatt or horsepower with the kilowatt-hour what is known as the load factor must be known. In ordinary practice the latter may vary from 30 per cent or even lower to 100 per cent. For instance, the superpower survey takes the load factor in connection with railway electrification as 50 per cent to 53 per cent, in which case 1 horsepower demand would represent a consumption of some 5,230 kilowatt-hours per year.

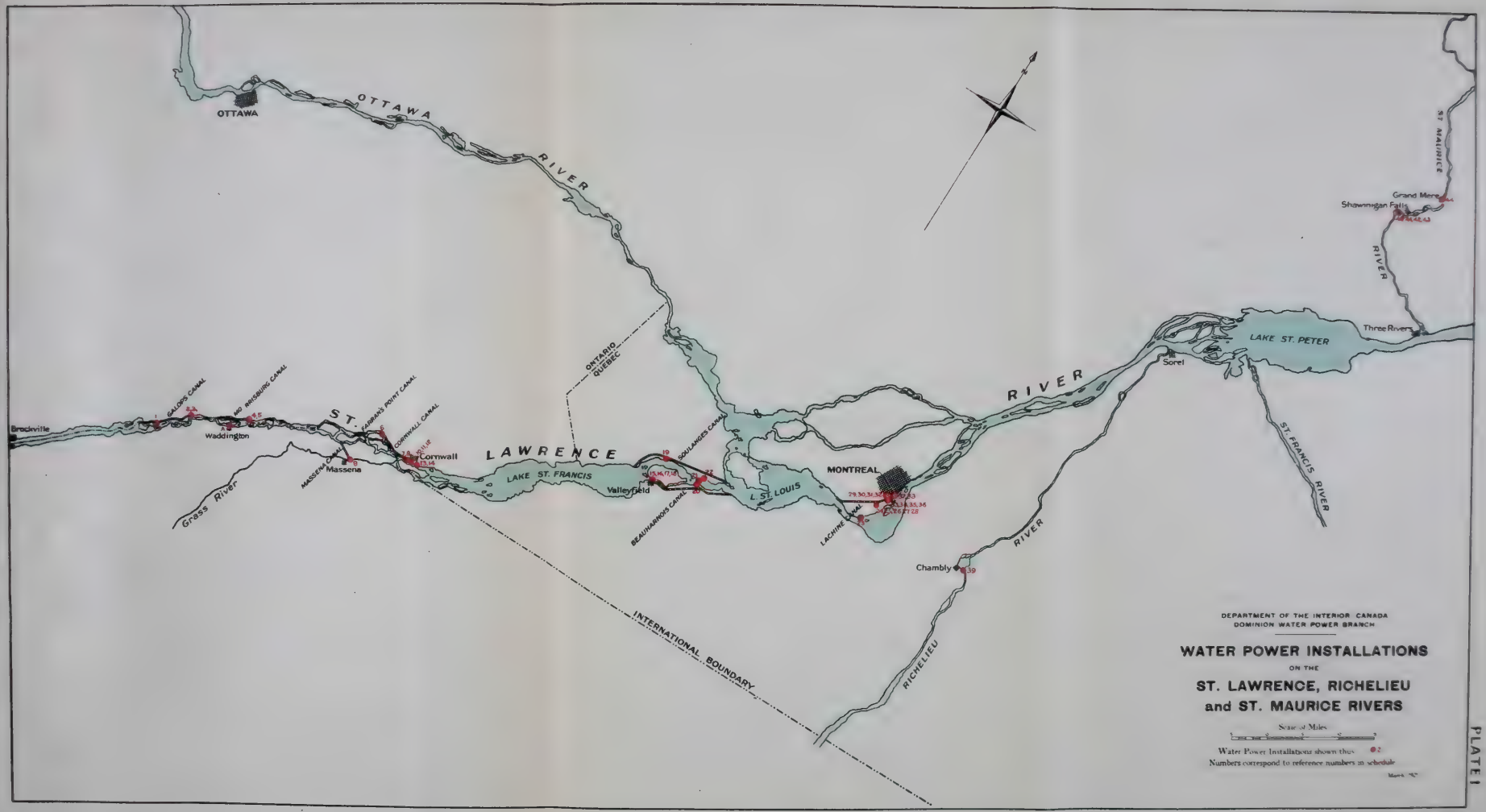
TABLE No. 2.—*Installed turbine capacity*—Continued.

Plan No.	Index No.	Name of owner.	Location.	Head in feet.	Turbines installed.		Remarks.
					Number of units.	Horsepower.	
		ALONG ST. LAWRENCE IN CANADA—continued.					
15	2MC$_{7}$	Valleyfield Electric Co.	Valleyfield, Province of Quebec.	10	2	135	
16	2MC$_{16}$	Montreal Cottons Co. (Ltd.).	do	10	30	8,800	
17	2MC$_{19}$	McDonald & Robb	do	8	4	110	
18	2MC$_{22}$	City of Valleyfield	do	10	5	300	Waterworks.
19	2MC$_{23}$	Department railways and canals.	Soulanges Canal, near Coteau du Lac.	19		700	
20	20MC$_{4}$	Canadian Light & Power Co. (Ltd.).	St. Timothee, Province of Quebec.	50	4	30,400	
21	2MC$_{1}$	Montreal Light, Heat & Power Consolidated.	Cedars	30	12	129,600	2 units being installed at 10,800 horsepower each.
22	2MC$_{6}$	do	Soulanges Canal, near Cedars.	50	3	16,050	
23	2OA$_{4}$	do	Lachine Rapids	14	12	15,800	
24	2OA$_{18}$	Montreal Blanket Co.	Lachine Canal Lock 4, Montreal Cote, St. Paul.	8	2	80	
25	2OA$_{29}$	C. Gilmore Co	do	7	1	50	
26	2OA$_{28}$	Mount Royal Mill & Manufacturing Co. (Ltd.).	do	6	4	232	
27	2OA$_{19}$	C. O. Clark & Bros	do	8	1	24	
28	2OA$_{31}$	Department railways and canals.	do	8		450	
29	2OA$_{30}$	Grier Timber Co. (Ltd.).	Lachine Canal Lock 3, Montreal, Seigneur Street.	9½	1	198	
30	2OA$_{17}$	Sherwin Williams Co. (Ltd.).	do	14	3	390	
31	2OA$_{3}$	Canada Box Board Co. (Ltd.).	do	9	2	180	
32	2OA$_{25}$	Ogilvie Flour Mills (Ltd.).	do	8	9	593	Glenora mill.
33	2OA$_{21}$	Consumers Cordage Co. (Ltd.).	do	6	1	162	
34	2OA$_{26}$	Jas. Shearer Co. (Ltd.)	do	8	2	175	
35	2OA$_{27}$	Canadian Jewellers (Ltd.).	do	9	1	75	
36	2OA$_{20}$	Belding-Paul Corticelli Silk.	do	9	2	198	
37	2OA$_{22}$	Ogilvie Flour Mills	Lachine Canal Locks 1 and 2, Montreal.	14	4	1,625	Royal mill.
38	2OA$_{24}$	do	do	14	5	607	Corn Products Mill
		Total installed capacity in Canada.				218,031	
		ALONG ST. LAWRENCE RIVER IN UNITED STATES.					
A		New York & Ontario Power Co.	Waddington, N. Y.	9		600	
B		St. Lawrence River Power Co.	Massena, N. Y.	42		86,000	
		Total installed capacity in United States.				86,600	
		ON RICHELIEU RIVER AT CHAMBLY.					
39	2OJ$_{1}$	Montreal Light, Heat & Power Consolidated.	Chambly	31	8	21,600	

TABLE No. 2.—*Installed turbine capacity—Continued.*

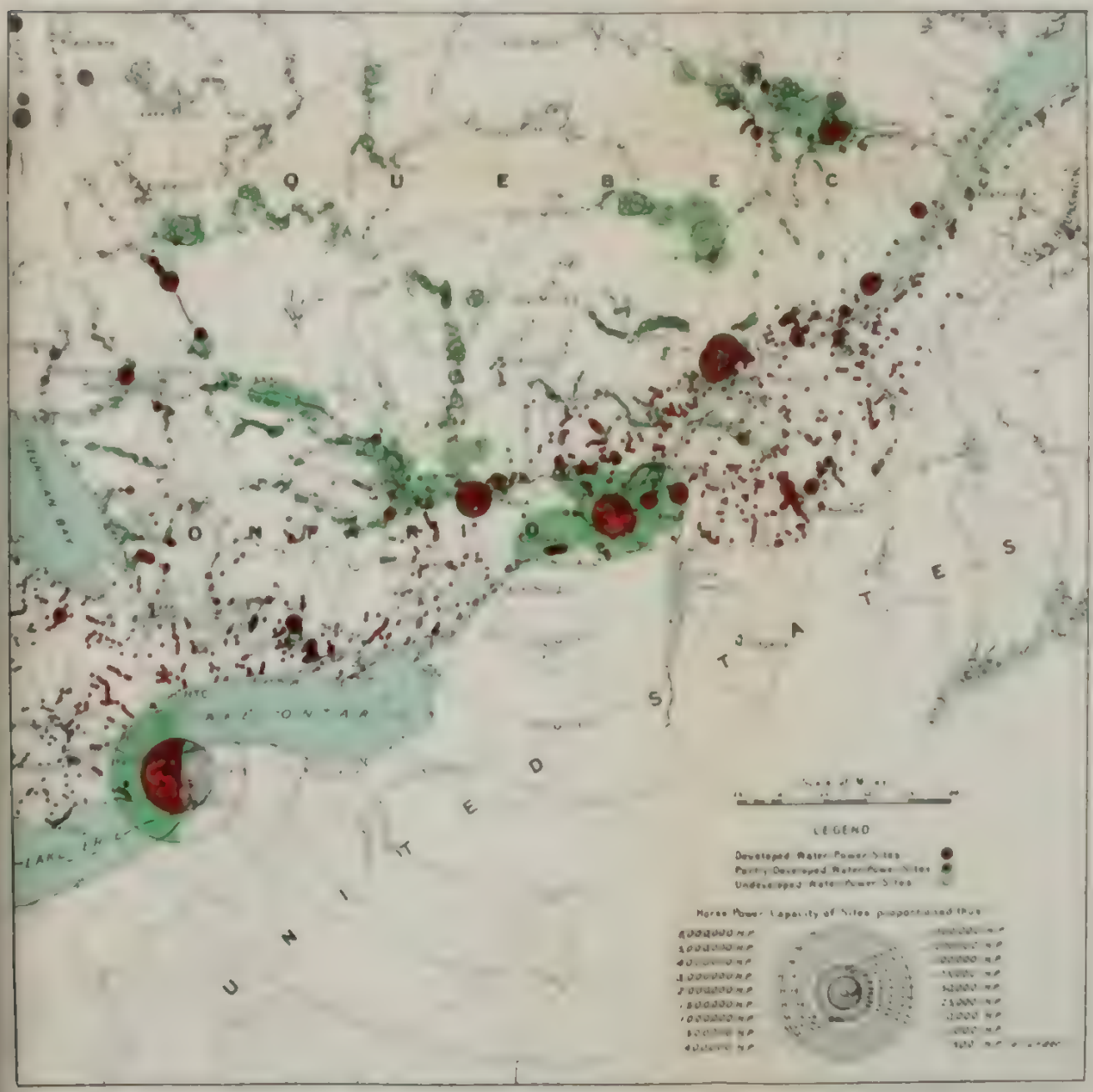
Plan No.	Index No.	Name of owner.	Location.	Head in feet.	Turbines installed.		Remarks.
					Number of units.	Horsepower.	
		ON ST. MAURICE RIVER AT SHAWINIGAN FALLS AND GRAND MERE.					
40	$2NG_1$....	Shawinigan Water & Power Co. (Ltd.).	Shawinigan Falls....	148	6	58,500	Plant No. 1.
41	$2NG_2$....	.....do.....	.....do.....	148	5	90,000	Plant No. 2 (1 new unit being installed, 42,000 horsepower).
42	$2NG_{11}$...	Belgo Canadian Pulp & Paper Co. (Ltd.).	.....do.....	140	20	17,910	
43	$2NG_{10}$...	Northern Aluminium Co. (Ltd.).	.....do.....	140	11	52,325	
44	$2NG_3$....	Laurentide Power Co. (Ltd.).	Grand Mere.....	76	6	120,000	2 new units being installed, 21,000 horsepower each.
		Total installed capacity.	.....	.....	.....	338,735	

(Compiled by Dominion Water Power Branch, Ottawa, Mar. 21, 1921.)



Senate Doc. No. 114. 67th Cong. 2d Sess.

DEPARTMENT OF THE INTERIOR, CANADA
DOMINION WATER POWER BRANCH



AVAILABLE WATER POWER IN CANADA

WITHIN

300 MILES OF THE LONG SAULT

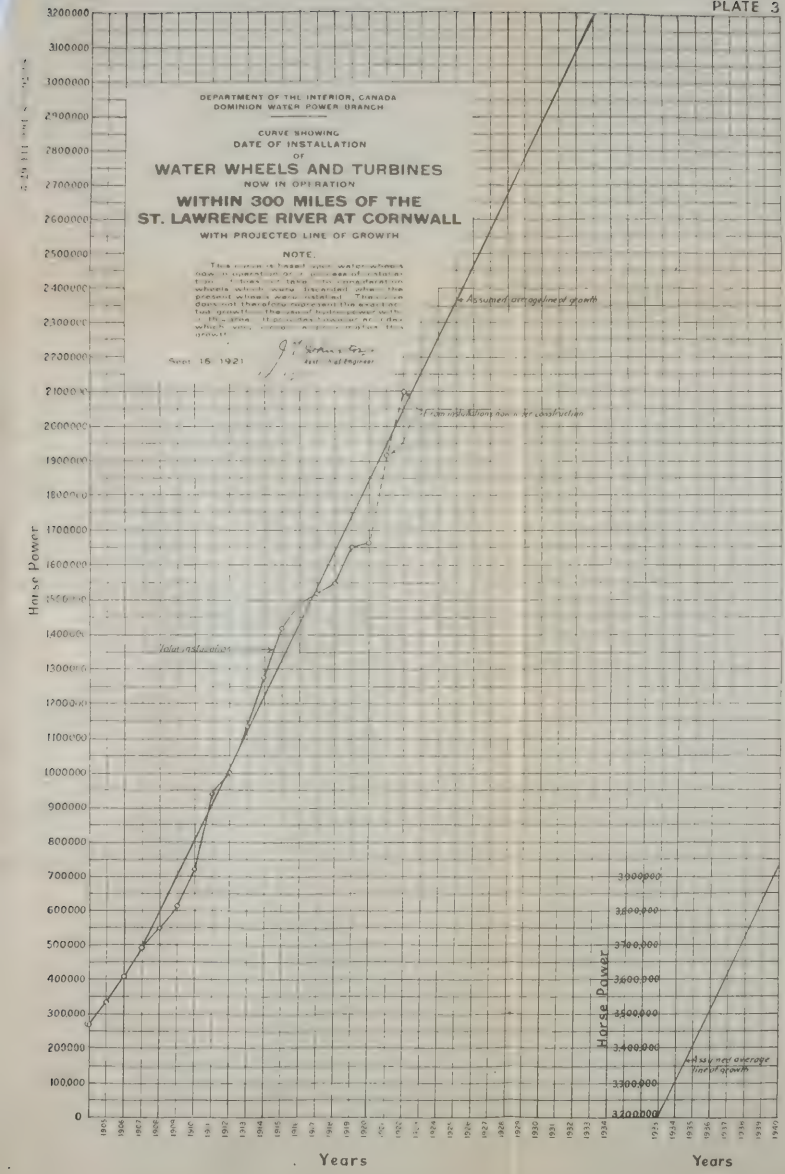
ON THE

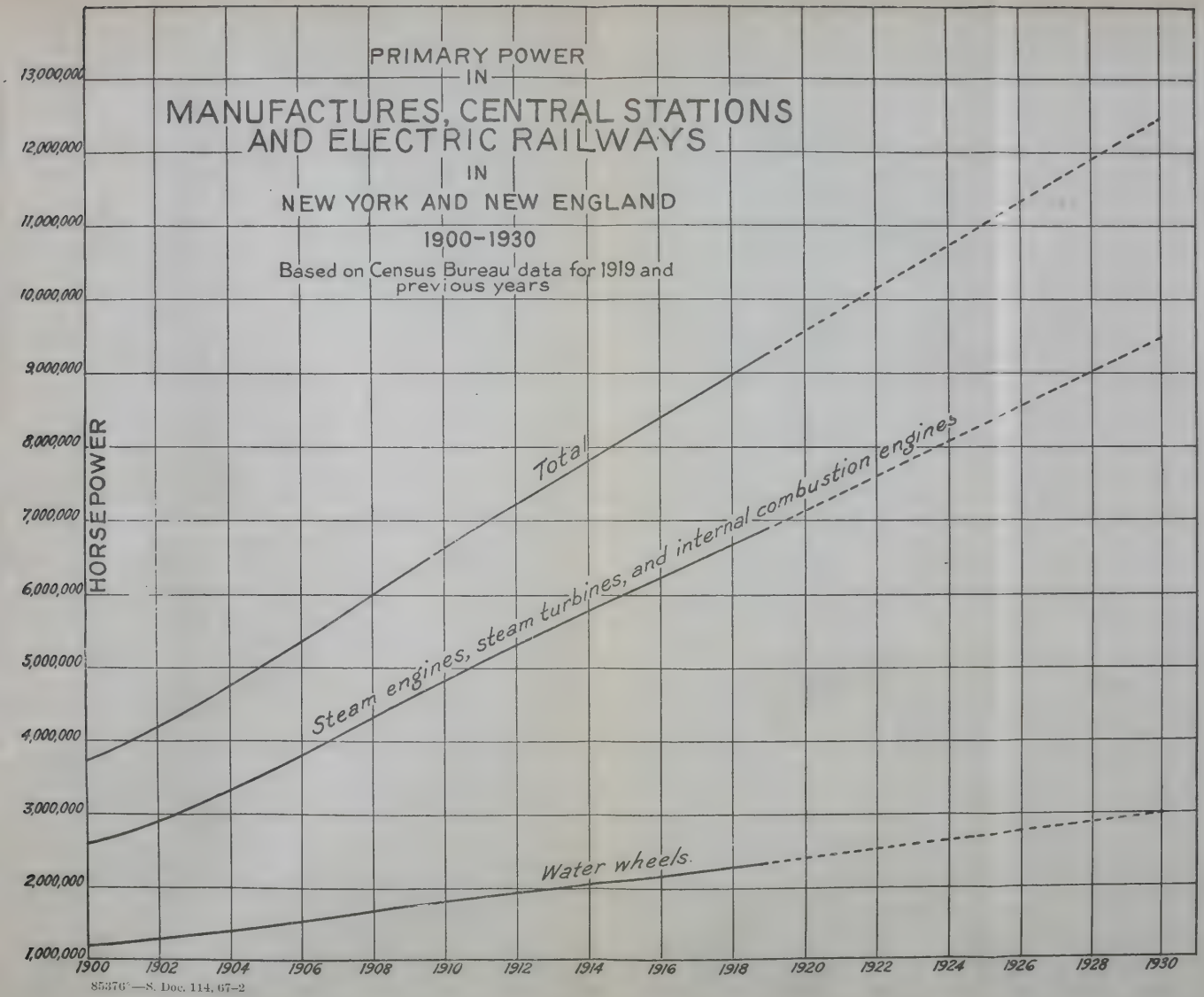
ST. LAWRENCE RIVER

INCLUDING THE UNDEVELOPED POWER ON THE ST LAWRENCE RIVER

Senate Doc. No. 114 67th Cong. 2d Sess.

PLATE 3


DEPARTMENT OF THE INTERIOR, CANADA
DOMINION WATER POWER BRANCH
CURVE SHOWING
DATE OF INSTALLATION
OF
WATER WHEELS AND TURBINES
NOW IN OPERATION
WITHIN 300 MILES OF THE
ST. LAWRENCE RIVER AT CORNWALL
WITH PROJECTED LINE OF GROWTH
NOTE.
Sept 15 1921
Assumed average line of growth
Horse Power
Years
Horse Power
Years



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IMPROVEMENT OF THE ST. LAWRENCE RIVER.

PART VI.

CONCLUSIONS AND RECOMMENDATIONS.

In submitting its conclusions and recommendations the commission has thought it well to discuss in some detail the various points demanding consideration in connection with this many-sided problem.

An analysis of the testimony submitted makes it clear that the consensus of opinion in the two countries, as revealed at the public hearings, while far from unanimous, was on the whole distinctly favorable to the proposed improvement of the St. Lawrence. Broadly speaking, it may be said that public sentiment throughout the Middle Western and Western States from Ohio to Idaho was almost unreservedly in favor of the deep waterway. The only evidence submitted on behalf of the people of the Mississippi Valley was also favorable. Various organizations and individuals in the Eastern States expressed themselves as approving of the project. On the other hand, evidence was not wanting of a widespread sentiment in some of the Eastern States antagonistic to the project. On the Canadian side, anything like general approval of the undertaking was confined to the Province of Ontario. In the other Provinces, public sentiment appeared to be either indifferent or more or less hostile.

The situation in Canada perhaps calls for some explanation, not so much as to those who frankly opposed the improvement, the opposition in Canada being based largely on the same grounds as in the United States, but rather as to the lack in Canada of anything like the unanimity of favorable sentiment noticeable on the American side of the region tributary to the Great Lakes. In the first place it appeared at the hearings that many Canadians were preoccupied with the merits of alternative routes to the seaboard. This was particularly noticeable in the western Provinces, where very keen interest was expressed in the possibilities of the Hudson Bay route, to which the Dominion Government had more or less committed itself some years ago, and upon which it has already expended over $20.000,000, and expects to spend another $17,000,000. In the east a similar sentiment was found in Montreal and North Bay favorable to the proposed Georgian Bay route, which has been before the Canadian public for many decades.

But a more potent, though perhaps less obvious, reason for the comparative lack of enthusiasm on the Canadian side will be found in the radically different character of the two regions, Canadian and

American, tributary to the Great Lakes. The United States tributary area consists of a compact group of States, an immense irregular parallelogram, with one end resting on the Rocky Mountains and the other embracing the greater part of the coast line of the Great Lakes, with most of their harbors. This area contains a very industrious, progressive, and ambitious population of approximately 42 million people. The phenomenal growth of such cities as Chicago and Milwaukee, Detroit, Buffalo, Cleveland and Toledo, Duluth, Minneapolis and St. Paul, Omaha and Denver, is in itself a sufficient indication of the extent to which this region has been favored by nature. To take but two of these, the population of Chicago has grown in 60 years from 109,000 to 2,700,000, and of Detroit from 45,000 to 1,000,000.

The resources of the region are both varied and enormous in extent, and they are particularly rich in the raw materials of the basic industries. Its soil—comparatively little of which is barren—produces a large percentage of the national harvest of all the important grains and root crops, and feeds millions of cattle, hogs, and sheep. In spite of an enormous production for years past, this territory still contains immense resources in iron ore, copper, coal, and timber. It not only feeds its own population, but produces substantial surpluses for export to domestic and foreign markets. It is at one and the same time the largest producing area of the United States and a very large consumer of raw material and manufactured products from abroad.

In this connection it was stated in evidence that the center of wheat production for the entire United States is in southeast Nebraska, of corn in Illinois, of oats in southeast Iowa, of potatoes in Wisconsin, of wool in Wyoming, of swine in Illinois, of cattle in Kansas, of butter in Illinois, of cheese in Wisconsin, of eggs in Iowa, of farm acreage generally in central Missouri, of farm values in Iowa, of meat packing in Iowa, of iron ore in Minnesota, of automobiles in Michigan, of rubber goods in northern Ohio, of bituminous coal reserves in Nebraska, and of population in Indiana. Taking alone the territory economically tributary to Chicago, it was pointed out that the agricultural production according to the 1920 figures was valued at $7,863,000,000, the mineral production at $1,888,000,000, and the industrial production, based on the figures of 1914, at over $6,853,000,000. The city of Chicago itself has grown industrially from a total value of manufactured products in 1860 of $20,000,000 to an estimated total in 1920 of $6,500,000,000.

The banking and other financial institutions of the area are strong and enterprising. The capital and surplus of Chicago banks were given as $250,000,000, total deposits (September, 1920), $1,829,000,000, and cash reserves, $500,000,000. The Ninth District of the Federal Reserve Bank, extending from Sault Ste. Marie to the western boundary of Montana, had in 1919 some 3,720 banks with an aggregate capital of $130,000,000, total resources of $1,978,000,000, and deposits of $1,688,000,000.

Altogether, these Middle Western and Western States are equipped in every way to take full advantage of the transportation facilities promised by the proposed deep waterway for the development of trade both with the Atlantic and Pacific seaboards of the United

States and with overseas countries. And, further, they are almost compelled to seek this new outlet to the sea by reason of the fact that the existing transportation agencies have for some years past found it exceedingly difficult to handle the situation. As a matter of fact, it is apparent that, to keep pace with the industrial and other development of this very rich territory, every practicable means of transportation will ultimately have to be brought into play.

On the other hand, the region in Canada similarly tributary to the suggested waterway consists of two distinct areas of productive land separated by a long narrow stretch of comparatively unproductive country, roughly, in the form of an hour-glass, one end being the eastern portion of the Province of Ontario, generally called Old Ontario, and the other the prairie Provinces of Manitoba, Saskatchewan, and Alberta, while the neck of the hour-glass is the sparsely populated region north of Lake Huron and Lake Superior. This region contains natural resources in timber, minerals, and cultivable land immense in value and extent, but its population in proportion to its area is small and likely to remain so for some years to come.

The compactness and uniform productiveness of the United States tributary area are lacking in the Canadian area. The population of the latter is about one-tenth of the former. Its resources as a whole are rich and varied, but its production falls very far below that of the United States area, particularly in manufactures. Except in grain, it has nothing approaching the same quantity of products to fill the holds of vessels sailing from Great Lakes ports to overseas ports, and it offers to-day only a comparatively small market for return cargoes. So far from its population and industrial development having outrun its transportation facilities, the fact is that at the present time the railways of Canada are considerably ahead of the requirements of the country.

Another point that should not be forgotten in considering the characteristics of the Canadian and United States sections of the tributary area and their ability to make effective use of the proposed waterway is the unique advantage enjoyed by the United States area in the possession of Lake Michigan, which runs far down into the heart of this territory. The immense coast line of Lake Michigan, with its numerous excellent harbors each linked up with the network of railways which covers the Middle West, puts all the surrounding territory in a most favorable position to take full advantage of the transportation facilities offered by the new waterway. It may also be noted that the ports of Lake Michigan have a decided advantage over those of Lake Superior by reason of the fact that when a deep-draft vessel has entered Lake Huron it can pass into Lake Michigan without the necessity of navigating the channels of the St. Marys River and the locks at Sault Ste. Marie.

Another fact that may perhaps help to explain the Canadian attitude is that for many decades past Canada has pursued a definite and progressive policy of waterways improvements, involving altogether an enormous expenditure, particularly when her comparatively sparse population is taken into consideration. The attitude in some parts of Canada appears to be that while in the course of time the Dominion might be expected to undertake the improvement of the upper St. Lawrence as a logical step in the creation of a deep-

water route from the sea to the head of the Great Lakes, the need for the improvement at the present moment is not so apparent in Canada as it appears to be in the United States.

The opposition to the suggested improvement centered largely in the State of New York, but was also supported by representatives of various public bodies in New England and in some of the Atlantic Coast States south of New York, as well as in the city of Montreal. The commission is satisfied that many of those who have opposed the project did so because they were convinced that it was impracticable and not in the public interest. It is equally satisfied, however, that much of the opposition had its source in what might be called local patriotism. That is to say, that many citizens of Buffalo, Montreal, New York, Albany, Boston, and Philadelphia were determined to oppose the project mainly because they believed that it would adversely affect the interests of Buffalo or Albany or the New York Barge Canal, or of the great seaports of New York, Philadelphia, Montreal, and Boston. On the other hand, the demand for the waterway comes mainly from the area which is most vitally concerned in the opening up of a new transportation route to the seaboard.

While a great deal of most valuable testimony was put before the commission at the various public hearings, it need hardly be said that the commission has felt itself in no sense bound to confine its consideration to, or to base its conclusions solely upon, that testimony. The investigation upon which it has been engaged was not in any sense a judicial inquiry, and was not therefore governed by the limitations imposed by the ordinary rules of evidence. The commission conceived its duty to be to get at the real facts wherever they might be found—facts that would lead to a sound conclusion. Not only therefore has every latitude been given to those who appeared before the commission, for or against the project, both as to the character of their testimony and how and when it should be submitted, but the commission has spared no effort to supplement or correct this information from other sources.

Certain outstanding facts or considerations emerge from the great mass of testimony. These have already been discussed in Parts III and IV, and the commission now submits its conclusions thereon. They will be considered under the general headings of navigation, economics, engineering, and water power.

NAVIGATION.

Ocean ships on inland waters.—The commission believes, from the evidence before it, that ocean-going ships of suitable draft would find no serious difficulty in navigating the deepened St. Lawrence and the Great Lakes. The physical obstacles which, in the opinion of opponents of the undertaking, would make the proposed waterway impracticable are its long, restricted, and tortuous channels of insufficient depth, fog, and ice conditions, time lost and damage sustained in getting through locks, and the limited navigation season. The commission's conclusion that these physical obstacles would not be sufficient to deter ocean-going ships from coming up into the Lakes is based, among other things, on the two unquestioned facts that for many years past ocean-going ships have successfully navi-

gated the St. Lawrence for a distance of approximately 1,000 miles, and that at the same time the big lake freighters have successfully navigated the Great Lakes and their connecting channels.

The St. Lawrence Ship Channel below Montreal is long, restricted, and tortuous, in the sense in which those terms have been used at the hearings. It differs in no material respect from the connecting waterways of the Great Lakes, except in its greater depth. The Lower St. Lawrence and the Gulf are more or less subject to fog and ice conditions. Nevertheless, although this inland waterway is open to trade only about 7½ months in the year as against the 12 months' period of the Atlantic coast ports, the port of Montreal actually handles a greater volume of foreign trade than any port on the American continent with the single exception of New York; and the percentage of casualties compares very favorably with the percentage in connection with Atlantic coast ports.

Similarly, although the Detroit River is subject to practically all the physical obstacles mentioned above, the fact remains that the tonnage and commerce passing up and down this river during the restricted season of navigation have grown by leaps and bounds from the comparatively insignificant figures of 50 years ago to a present vessel tonnage of about 60,000,000, with a freight tonnage of 80,000,000 valued at over $1,000,000,000.

If the physical obstacles of the St. Lawrence have not been sufficient to prevent the building up of a great foreign trade to and from Montreal by ocean-going ships, and similar obstacles have not prevented the building up on the Great Lakes of a commerce immensely greater than that through the Suez Canal, carried by vessels many of which now exceed 600 feet in length, it does not seem reasonable to suppose that the same obstacles would prevent ocean-going ships coming up the St. Lawrence into the Great Lakes, given a waterway of sufficient depth. So far, of course, the commission is dealing with the physical rather than the economic practicability of the project.

It may be added that the commission's view is supported by the opinions of men who have had many years' practical experience in navigating either the St. Lawrence or the Great Lakes, and who are equally agreed that the physical conditions on the St. Lawrence and on the Great Lakes, with their connecting waterways, offer no particular problem to ocean-going ships.

Prevailing drafts of ocean ships.—Arguments against the waterway that it would not be deep enough for the prevailing draft of ocean-going ships seem to have been based on the assumption that the great liners, such as those plying between New York and Liverpool, were expected to go up into the Great Lakes. That, of course, was an unwarranted assumption. The type of ocean vessel that would probably use the St. Lawrence route would be the average-sized tramp. In this connection the commission was impressed with the statement of Maj. Gen. Black, formerly Chief of Engineers of the United States Army, to the effect that out of 14,513 steamships listed in Lloyd's Register for 1918–19, 81.45 per cent had drafts of 25 feet or less and 99.32 per cent drew 30 feet or less. This statement, confirmed by other evidence secured by the commission, makes it clear that 30-foot canals on the St. Lawrence and in the Welland

would accommodate all the existing ocean-going vessels of the world with the exception of such deep-draft vessels as the great modern liners; and even 25-foot depths in the same canals would be sufficient for a very large majority of ocean craft.

The St. Lawrence ship channel below Montreal now has a depth of 30 feet, and is being carried down to 35 feet. The Welland Ship Canal, at present under construction, will have a depth of 30 feet in the locks and 25 feet in the canal, with provision for deepening to 30 feet. Of the five locks at Sault Ste. Marie, two on the United States side have a depth of nearly 25 feet and the Canadian lock a depth of 23 feet. When it becomes desirable to do so in the interests of navigation, there will be no difficulty in reconstructing one of the older American locks so as to accommodate vessels of approximately 30 feet draft.

Similarly it may be assumed that sooner or later the river channels above Lake Erie as well as the harbors—at any rate, the more important harbors—will be further deepened, in accordance with the established policy in both countries of meeting the ever-increasing draft of lake vessels with deeper channels and harbors. The commission recognizes the fact that the proposed improvement of the St. Lawrence, if the maximum benefit is to be derived therefrom, must involve the deepening of river channels and also of at least some of the lake harbors—what may be regarded as pivotal harbors—but it is equally satisfied that the deepening of these harbors and channels would be demanded sooner or later to meet the requirements of lake shipping, even though the St. Lawrence waterway were never built. As a matter of fact, the very comprehensive improvements to the harbor of Toronto, now well advanced and estimated to cost on completion some $25,000,000, provide for a draft of 30 feet, and a number of other lake cities have worked out plans for similar improvements.

Taking, however, the situation as it appears to-day above Lake Erie, the evidence seems to show that the existing depths in the Detroit and St. Clair rivers, Lake St. Clair, and the St. Marys River, as well as in most of the principal harbors of the Great Lakes, would accommodate a large proportion of the vessels now operating on the high seas.

Relative costs of ocean and lake vessels.—Evidence as to the relative cost of construction of lake vessels and ocean vessels varied considerably, partly because some of the figures related to present-day costs and other to prewar costs; partly because the cost of constructing ocean-going vessels at seaboard shipyards was being compared with the cost of constructing lake vessels at lake shipyards; and also because some witnesses were apparently comparing two quite different things; i. e., ocean general cargo vessels and lake bulk carriers. It appears that the cost of lake package vessels built at lake shipyards in 1920 ran from $125 to $135 per ton, while the same shipbuilding company was prepared to turn out ocean-going vessels of the same type for from $178 to $185 per ton. The relative costs in 1921 are said to be $120 and $140, respectively. These building costs may of course be materially lowered in the course of the next few years, without, however, necessarily affecting the relation between one and the other. The commission does not find in the relative cost of building an ocean-going vessel and a lake vessel, each designed

to carry the same kind of cargo, any serious arguments against the practicability of the proposed waterway.

Composite vessels.—At the various hearings a good deal of discussion centered around the practicability of a composite vessel combining the advantages of the ocean tramp and the lake carrier. The consensus of opinion seemed to be that the design of such a craft was quite within the bounds of naval architecture. In the opinion of the commission the shipbuilding genius which developed the present type of lake freighter is quite capable of producing a boat equally adaptable to service on ocean, lake, and river. The creation of such a vessel does not, however, appear to be a vital factor in the problem of developing commerce between lake ports and ocean ports, in view of the fact that, as already stated, the present types of ocean freight carrier would find no serious physical difficulty in navigating the lakes and their connecting rivers.

The time factor.—Another element in the problem of lake and ocean navigation is the time factor. It was stated in evidence that the time lost in passing through locks and canals and restricted natural channels on the St. Lawrence and the Great Lakes would prove a fatal barrier to the adoption of that route. The facts, however, do not appear to sustain that contention. The average speed of lake freighters is given as 11 or 12 miles an hour in the open lake, and in restricted channels about 8 or 10 miles an hour. The mean running time for the round trip from Erie ports to Superior ports and back is 10 or 10½ miles an hour. The average time lost in passing through locks and canals is one hour for each lock. As the speed of the average ocean tramp is given as 10 to 12 miles an hour, there does not appear to be any material difference between the time on the open sea and on such a water system as the St. Lawrence and the Great Lakes. While recognizing that the present type of ocean vessel, because of its relatively heavier build and greater draft, would not make quite the same time as the lake vessel in restricted inland waters, the commission is of the opinion that losses of time due to delays in locks and restricted speed in canals and river channels would not prove a serious obstacle to the use of the proposed route by ocean-going vessels.

The commission is inclined to agree with the statement that where there is a productive interior ships will proceed as far inland as physically practicable, and that the farther inland they can penetrate the greater will be the resulting economy and the more extensive the area benefited. Notable examples of rivers on which a considerable traffic has been developed by ocean-going ships are the Amazon, the Yangtse-Kiang, the Rhine, the Danube, the Columbia and Willamette, the Delaware, the lower Mississippi, and the St. Lawrence itself. It appears in evidence that the same rate of freight was paid New York to Bombay as New York to Calcutta, though the latter port was 2,000 miles farther and involved 90 miles of a tortuous river channel much more difficult than the St. Lawrence. It may also be noted that ocean shipping has to an increasing extent made Montreal its destination, although railways extend down both banks of the St. Lawrence from Montreal to Quebec.

Effect of diversions.—At the Montreal hearing the attention of the commission was drawn, both by the chairman of the Montreal

Harbor Commission and the president of the Shipping Federation of Canada, to the fact that through the diversion of water from Lake Michigan by the Chicago Drainage Canal the water levels in the St. Lawrence suffer, not only in that portion of the river which it is now proposed to improve, but also in the harbor of Montreal and in the dredged ship channel below Montreal. This matter is also referred to in the report of the engineering board.

This commission does not feel called upon to express any opinion as to the propriety or otherwise of the Chicago diversion, beyond observing that the engineering services of both countries have reported that the present diversion has had a certain definite effect in lowering the prevailing depths in all the lakes and connecting rivers below Superior, including the St. Lawrence, and particularly in the harbors and river channels, which had been repeatedly deepened at very great expense to meet the increasing demands of commerce.

Use of existing St. Lawrence canals.—The question was frequently asked at the hearings why the existing St. Lawrence canals were not used by ocean-going vessels if the water route between the sea and the Great Lakes were practicable. The evidence shows that at various times in the past the experiment has been tried of bringing small ocean vessels up into the Lakes for cargoes, but that it had not proved economically profitable because of the very limited cargoes that could be carried through the canals.

ECONOMICS.

Rail or water transportation.—No consideration of the economic practicability of the proposed St. Lawrence deep waterway can afford to ignore the important group of problems involving the relationship between rail and water transportation. In this group are included such questions as car and locomotive shortage, terminal congestion, terminal and transshipment charges, rail rates and water rates, marine insurance and refrigeration.

Unquestionably the rapid growth of sentiment favorable to the water route throughout the Middle Western and Western States has been due very largely to the serious situation created by the inability of the railroads to carry the ever-increasing load of traffic outbound and inbound between the West and the Atlantic seaboard. The feeling has been growing that, unless some solution should be found for the transportation problem, the progress of this important and ambitious group of States would be seriously checked, and it was believed that the all-water route to the sea by way of the St. Lawrence would go a long way toward solving the problem.

Rail congestion.—The evidence as to the fact and extent of congestion on the railroads of the United States, during the last few years, is too definite and abundant to admit of any serious question. Indeed, what conflict of opinion is found in the testimony applies not so much to the fact of congestion as to its causes and remedies. Was congestion brought about by the abnormal conditions arising out of the war, or is it the inevitable result of the growth of the nation's business outrunning its transportation facilities? Will it find its own cure in the gradual after-the-war readjustment of the country, or must a remedy be sought elsewhere, by the creation of new trans-

portation channels which will help to cure congestion by relieving the railroads of a material proportion of their burden?

Terminal conditions.—The situation is very similar as to conditions at the Atlantic coast terminals of the railways. Here also the fact of congestion is hardly disputed, indeed can not be seriously denied in the face of the numerous specific instances offered by witnesses at practically every hearing held in the West. Again, however, the questions were raised as to whether the existing congestion was temporary or chronic; and as to whether it could be remedied by the provision of additional facilities, or must seek relief by shifting some of its traffic load to another route.

The commission believes that, while it is physically practicable to bring both railroads and terminals up to the point where they could handle the traffic of the United States without serious congestion, the expense involved would be enormous, amounting in the opinion of experienced railroad executives to from $1,000,000,000 to $2,000,000,000 per annum over a series of years, and it is perhaps questionable if in the end the relief afforded would be comparable to that promised by the creation of an all-water route from the interior of the continent to the Atlantic seaboard. So far as Canada is concerned, it does not appear that congestion, either on the railroads or at the terminals, has been a serious problem, except perhaps for a limited period during the war. In fact, as stated elsewhere, Canadian railway facilities are still well ahead of population and production, and probably will be for some years to come.

Terminal and transshipment charges.—An important point in considering the relative advantages of rail, rail-and-water, and all-water routes is the question of transport and other charges at terminal and intermediate points. A great deal of evidence was submitted illustrating the extent to which terminal charges absorbed the profit on export shipments; and also the losses, particularly in grain, due to transshipment at intermediate points from lake boats to rail or canal boats. The argument, in the opinion of the commission, was well taken that much of this loss, both at transport points on the lakes and at the Atlantic terminals, would be avoided if goods could be shipped through without breaking bulk from lake ports to overseas ports.

Rail rates versus water rates.—Much testimony was also put before the commission as to all-rail rates and rail-and-water rates from inland points to the Atlantic seaboard, ocean rates from the Atlantic seaboard to Europe, and the probable saving on shipments by the proposed all-water route. While comparisons of this kind must necessarily be more or less conjectural in the absence of any definite information as to what actual rates would apply on shipments by ocean-going vessels from ports on the Great Lakes to European ports, the commission is inclined to the view that the St. Lawrence route would afford a material saving in transportation rates over any of the existing routes between points in the territory economically tributary to the St. Lawrence and overseas points.

Marine insurance.—The fact was urged more than once, in support of the contention that the St. Lawrence was a dangerous route, that the marine insurance companies charged higher rates to Montreal than to New York and other Atlantic ports. On the other hand, while

the fact was admitted by those who advocated the waterway, it was argued that this discrimination against Montreal was not justified by navigation conditions on the St. Lawrence. Previous to 1900 it appears that outside tonnage was allowed unrestricted navigation of that river between April 1 and October 31, without extra charge. In that year, however, the British North American clause was adopted, the effect of which was to handicap the St. Lawrence in the matter of rates. At that time there may have been some excuse for discrimination, but since 1900, it was urged, all the improvements asked for by shipping and insurance interests had been carried out by the Canadian Government, which has spent large sums of money in aids to navigation, and in improving the pilotage and other services, as well as in the establishment of signal, telephone, and telegraph stations, so that to-day the St. Lawrence is one of the most thoroughly marked waterways in the world. Since these improvements had been made, the size of steamers using the river had doubled, while the number of accidents had notably decreased. Nevertheless, the higher rates on cargoes and hulls were still maintained and restrictions on outside ships adhered to.

Without expressing any opinion as to the reasonableness or otherwise of the discrimination against the St. Lawrence, the commission believes that the difference in marine-insurance rates is not sufficiently serious to make it a factor in the transportation situation.

Refrigeration.—The evidence offered at the hearing makes it quite clear, in the opinion of the commission, that chemical refrigeration on steamers is more economical than icing on cars.

Foreign trade.—The commission has had placed before it a mass of testimony as to the area, population, resources, production and trade, foreign and domestic, of the territory economically tributary to the proposed deep waterway; both for foreign and coastwise trade; that is, trade with the Atlantic and Pacific seaboards. This testimony very largely confirms the view that the territory in question not only contributes more than any other area to foreign exports, but constitutes an important consuming area for imports. It also establishes the fact that a very large volume of trade is now carried on between the region tributary to the Lakes and the Atlantic, and, to a lesser extent, the Pacific seaboard.[1] As already stated, the bulk of this trade must be credited to the American rather than the Canadian side of the area.

It therefore appears from the testimony that there already existed in the region tributary to the Great Lakes abundant material, raw and manufactured, to furnish cargoes for ocean ships from Lake ports to overseas and coastwise ports; that these commodities already formed a very large part of the foreign and domestic trade of the two countries; that in many instances, with the existing transportation facilities, the quantity of foreign exports was restricted because of the difficulty in guaranteeing delivery in a reasonable time, and in other cases the creation of foreign markets was made more difficult by excessive transportation charges; that similar conditions affected shipments to seaboard points; that the large and growing demands of the same region for foreign products and products of

[1] It is to be understood that exports and imports do not include trade between the United States and Canada. For the purposes of this report the two countries are, as far as practicable, considered as one.

the Atlantic and Pacific seaboards would insure ample return cargoes; and that the banking and other facilities of this region were adequate to take care of its foreign trade, whether that trade followed existing channels or was diverted to such a new route as the St. Lawrence waterway.

Tidewater transfer.—A variety of opinion has been expressed as to the extent to which commerce would find it profitable to transfer cargoes at Montreal or some other tidewater point rather than ship through from Lake ports to overseas ports. The commission feels that so many factors enter into this problem that it would be hazardous to offer a positive opinion at the present time. It is, however, of the opinion that, even if it should be found inadvisable for certain classes of ocean ships to go up into the Lakes, or for certain cargoes to be shipped through without transfer at tidewater, the creation of the deep waterway would nevertheless be justified, as it seems probable that there would still be a material saving in freight and other charges by way of the St. Lawrence over the existing routes.

Shipbuilding on the Lakes.—A comparatively minor point in the problem of providing a deep water channel through the Great Lakes to the sea is the effect it might have on the shipbuilding industry. Previous to the war these plants were devoted mainly to the production of lake shipping; but the insistent demands for ocean ships to carry food and munitions to Europe forced them to turn more and more to that branch of shipbuilding, until in 1918 the plants on the United States side of the Great Lakes actualy built and delivered a very considerable proportion of the total tonnage constructed by the country in that year. The capacity of these plants was more than doubled during the war, and this applies to both sides of the Lakes. It appears that with this equipment, with thousands of skilled workmen trained in the art of shipbuilding, and with their strategic position in relation to raw materials, the shipbuilding plants of the Great Lakes would be in a position to compete on very favorable terms with plants on the seaboard in the construction of ocean-going ships, if a deep waterway were available by which these ships could be taken down to tidewater.

Alternative routes.—Although not required to do so by the terms of the reference, the commission feels it desirable, particularly because of the strong local interest expressed at some of the public hearings, to refer very briefly to certain waterways advocated as alternative routes from the interior of the continent to the seaboard. These are the New York State Barge Canal, the projected Oswego Ship Canal, the Richelieu and Lake Champlain route, the proposed Georgian Bay Canal, the Hudson Bay route, the Mississippi route, and the Pacific and Panama route. The history and characteristics of these routes, as well as their advantages and disadvantages, have been dealt with in Parts II and III. The commission is convinced that none of them offers the advantages of the St. Lawrence route, either as a means of relief for the acute transportation situation, or as a channel for the carriage of commodities between the region tributary to the Great Lakes and domestic and foreign seaboard points.

Treaty provisions.—It may be convenient at this point to set out the provisions of various treaties between Great Britain and the

United States, so far as they affect the waters included in the present investigation.

By Article VII of the Webster-Ashburton treaty, 1842, it was agreed that the channels in the river St. Lawrence on both sides of the Long Sault Islands and of Barnhart Island, etc., "shall be equally free and open to the ships, vessels, and boats of both parties."

By Article IV of the reciprocity treaty of 1854 the right to navigate both the St. Lawrence below the point where it ceases to be the boundary and the canals in Canada used as part of the water communication between the Great Lakes and the Atlantic was temporarily secured to the United States. That right, of course, lapsed with the treaty.

By Article XXVI of the treaty of Washington, 1871, the—

"navigation of the River St. Lawrence ascending and descending from the forty-fifth parallel of north latitude, where it ceases to form the boundary between the two countries, from, to, and into the sea, shall forever remain free and open for the purposes of commerce to citizens of the United States, subject to any laws and regulations of Great Britain or of the Dominion of Canada not inconsistent with such privilege of free navigation."

By Article XXVII of the same treaty, the British Government engaged to urge upon the Dominion Government to secure to the citizens of the United States the use of the Welland, St. Lawrence, and other canals in the Dominion, on terms of equality with the inhabitants of the Dominion.

No formal action was ever taken by Canada in this connection, but it appears that from 1854, notwithstanding the abrogation of the reciprocity treaty, United States vessels continued to enjoy the use of all the Canadian canals on terms of equality with the vessels of Canada. In 1905 the Dominion abandoned the system of canal tolls, since which time all Canadian canals have been free to all vessels with their cargoes or passengers, whether these were Canadian or American. For some time Canadian vessels were only granted the use of such United States canals connecting boundary waters as those at Sault Ste. Marie, but as the result of negotiations between the Canadian and United States Governments, this privilege was finally extended to the New York State canals.[1]

By Article I of the treaty of January 11, 1909, Great Britain and the United States agreed that the navigation of all navigable boundary waters (between the United States and Canada)—

"shall forever continue free and open for the purposes of commerce to the inhabitants and to the ships, vessels, and boats of both countries equally, subject, however, to any laws and regulations of either country, within its own territory, not inconsistent with such privilege of free navigation and applying equally and without discrimination to the inhabitants, ships, vessels, and boats of both countries.

"It is further agreed that so long as this treaty shall remain in force, this same right of navigation shall extend to the waters of Lake Michigan and to all canals connecting boundary waters, and now existing or which may hereafter be constructed on either side of the line. Either of the High Contracting Parties may adopt rules and regulations governing the use of such canals within its own territory and may charge tolls for the use thereof, but all such rules and regulations and all tolls charged shall apply alike to the subjects or citizens of the High Contracting Parties and the ships, vessels, and boats of the High Contracting Parties, and they shall be placed on terms of equality in the use thereof."

[1] Canadian vessels are not, however, permitted to navigate the Hudson River and, without that, the privilege of navigating the canals is comparatively worthless.

It may be noted that the same right to navigate Lake Michigan during the life of the treaty had already been granted to Canada by the treaty of Washington, 1871.

ENGINEERING.

The engineering problems connected with the proposed St. Lawrence improvement were, as already mentioned, left in the first instance to the engineering board, who submitted their report to the commission in July and August, 1921. In the meantime the commission had assembled such technical data as was available, and in the course of its public hearings had received some additional information on certain aspects of the engineering problem. It may be said at once, however, that very little that was helpful was brought out at the hearings, which were devoted mainly to the economic problem.

Before outlining the principal features of the report of the engineering board the commission desires to put on record its appreciation of the admirable manner in which Col. Wooten and Mr. Bowden and their assistants have carried out the important task intrusted to them by the two Governments. The instructions to the engineering board make it clear that they were not expected to submit anything more than outline plans and lump-sum estimates, the period of 12 months allowed them for the work being considered insufficient for the preparation of detailed plans and estimates. While it was obviously impossible to deal exhaustively with such a very large and complicated engineering problem in 12 months, the engineering board has unquestionably, both in the matter of plans and of estimates, given the commission more detailed information than the strict letter of the instructions called for, and has put it in a form that leaves very little to be desired.

The commission is convinced that, in a matter of such unusual magnitude, involving engineering factors that are more or less debatable and affecting the interests of many millions of people, too much care can not be taken to insure the adoption of plans that will be beyond reasonable criticism, both as to the general scheme of development and the working out of its details. It is therefore desirable that, before any steps are taken to carry out the commission's recommendations, the plans of the engineering board, together with such comments or criticisms or alternative plans as have been filed with the commission by other engineers, should be referred back to the board enlarged by other leading members of the engineering profession, to the end that the whole question be given that further and complete study that its magnitude and importance demand.

As the report of the engineering board is filed as an appendix to this report, it will not be necessary to do anything more here than describe it in very general terms. The report proper is accompanied by three appendices, the first containing the detailed estimates, and the other two separate reports on the regulation of Lake Ontario, by Mr. Bowden and Col. Wooten, respectively. The drawings, some 64 in number, are in an atlas.

The engineering board divides the proposed works into two principal sections—the international, from Lake Ontario to Cornwall.

and the national or all-Canadian, from Cornwall to Montreal. Each of these again is subdivided. For the international section a combined scheme of navigation and power development is recommended. In the national section the board recommends a navigation development alone, but has made some preliminary studies of the power situation in case it should be decided at some future time to develop power. Its plans cover both a 25-foot depth and a 30-foot depth.

In the international section of the river, a distance of about 45 miles, Prescott to Cornwall, the fall in the river amounts to about 91 feet, which is overcome at the present time by four canals on the Canadian side—Galops, 7½ miles; Rapide Plat, 3⅝ miles; Farrans Point, 1½ miles; and Cornwall, 11 miles. The project of the board calls for the construction of a canal on the Canadian side of the river with a prism depth of 25 feet at low water. This canal extends from the head of the Long Sault Rapids down to Cornwall, a distance of about 8 miles, and is provided with two lift locks, 860 feet long by 80 feet wide, with a depth of 30 feet on the sills, as well as one pair of guard gates. One of the locks has a lift of 48 feet and the other 31 feet.

In order to concentrate the fall in the river so as to reduce the number of locks and lessen the mileage of restricted navigation, the plans call for the construction of a series of dams across the several channels of the river in the vicinity of the Long Sault Rapids. The damming of the river at this point consists briefly of the following: An embankment from the Canadian main shore to Sheik Island, the power houses from the foot of Sheik Island to Barnhart Island, the main dam from Barnhart Island to Long Sault Island, and the smaller dam from the head of Long Sault Island to the American main shore. The last mentioned dam, in addition to the purpose it serves as part of the general scheme for damming the river, is also designed to protect the Massena diversion canal and to assure its water supply. Besides meeting the needs of the Massena plant this dam will also produce 56,000 horsepower. The main dam is also designed so that it may be utilized for power purposes, and these two dams will make possible a development of power estimated at about 1,500,000 horsepower, which includes the 56,000 horsepower mentioned above.

In addition a control and protective dam is provided for about 20 miles up the stream at Ogden Island, with a lock, on the United States side, of the same dimensions as the lock at the Long Sault. Dikes will be built at various points on the American and Canadian sides above the dam. It is estimated that 4,780 acres will be flooded on the Canadian side of the boundary and 6,320 acres on the United States side. The flooding on the Canadian side presents the more serious problem, as it involves the protection of certain small towns and the inundation of several villages, a considerable area of cultivated land, and a number of burial grounds that have been in existence for about a century.

The entire works within the international section, including the above-mentioned flooded areas, and power houses equipped to deliver 1,500,000 horsepower, are estimated to cost $159,000,000. Nothing, however, is included for putting out of commission the four existing canals on the Canadian side, nor is any allowance made

for the charter rights and privileges, whatever they may be, of the New York & Ontario Power Co. at Waddington, N. Y.

A point demanding consideration in connection with the proposed works in the international section of the river is the relationship between the power works and the international boundary. It has been found that the most economical location for both the American and Canadian power houses is on Sheik Island, which is entirely on the United States side of the boundary. As it seems essential that each country ultimately should have the operation and control of those portions of the power works from which it will be supplied with its share of the developed power, the commission believes that the international boundary should be adjusted so as to leave each country's power house on its own side of the boundary. Should the plans of the engineering board be finally adopted, it would therefore be necessary to transfer to Canada something in the neighborhood of two hundred acres of United States territory, all of which would however be covered by water.

In the national section of the river, between Cornwall and Montreal, a distance of about 72 miles, the fall in the river amounts to about 134 feet, overcome at present by the Soulanges and Lachine Canals. The former overcomes three rapids, the Coteau, Cedars, and Cascades, the first at the outlet of Lake St. Francis, the second 9 miles lower down, and the last at the entrance to Lake St. Louis. The Soulanges Canal, 14 miles long, is on the north side of the river. The board proposes a canal 220 feet wide with a depth of 25 feet at low water, on the south side of the river, from Hungry Bay, on Lake St. Francis, to a point near Melocheville, on Lake St. Louis, a distance of 15 miles. The canal will be equipped with a guard lock as well as two pairs of flight locks, each 860 feet long and 80 feet wide, with 30 feet of water on the sills, and each with a lift of about 40 feet.

The present Lachine Canal, 8½ miles long, overcomes two rapids, the Sault Normand, just below the Victoria Bridge at Montreal, with a drop of 10 feet, and the Lachine Rapids, between Heron Island and the town of Lachine, with a drop of about 32 feet. The project of the board overcomes both rapids by a canal about 8 miles long with two lift locks, of the same dimensions as those mentioned above, and one guard lock. The combined lift is about 48 feet. The projected canal follows the same general route as the present canal for a part of its length and for the remainder lies substantially along the southerly and westerly outskirts of the city of Montreal.

In addition to these two canals, a certain amount of dredging is provided for in Lake St. Francis and Lake St. Louis.

All of the above-mentioned works, as well as certain protective works in the harbor of Montreal, are entirely in Canada, and below the point where the international boundary leaves the St. Lawrence. The cost is estimated at about $93,000,000, but, as in the case of the international section, nothing is provided for putting out of commission the existing canals, the Soulanges and Lachine. All the foregoing refers to the 25-foot depth in the canals. To get an additional 5 feet would increase the estimated cost by about $17,000,000. This includes the proposed canals in both the national and the international sections.

The annual operating and maintenance costs in connection with the recommended scheme are estimated at $2,562,000, of which $1,105,000 represents costs of navigation and $1,457,000 the amounts chargeable to power.

According to the report of the engineering board about 2,260,000 horsepower could be developed on the national section of the river, if this should at some future date be thought desirable, at an estimated cost of $220,000,000.

Regulation of Lake Ontario.—One of the questions in the reference which the commission is asked to answer is: "Will regulating Lake Ontario increase the low-water flow in the St. Lawrence Ship Channel below Montreal? And if so, to what extent, and at what additional cost?"

During the last 10 or 12 years the question of the regulation of Lake Ontario has been investigated from varying points of view by a number of engineers and commissions. It was discussed by the International Waterways Commission in their report on the regulation of Lake Erie, 1910; and considered by Mr. A. J. Matheson in 1918 in an unpublished report prepared for the Montreal Levels Commission. It was also dealt with by Mr. Francis C. Shenehon in his "Reports on the Regulation of the Niagara and the St. Lawrence Rivers."

In the present investigation, separate reports have been submitted to the commission by Col. Wooten and Mr. Bowden on the regulation of Lake Ontario. It may be noted that while the engineers adopted somewhat different methods, they reach substantially the same conclusion. This question has also been dealt with, more or less fully, in the reports of the Hydro-Electric Power Commission of Ontario, the New York & Ontario Power Co., and Hugh L. Cooper & Co.

A consideration of these various studies leads to the conclusion that by regulating the discharge of Lake Ontario through the St. Lawrence River the mean level of the lake may be raised without causing it to fluctuate beyond its stream limits of previous years, the low water flow of the St. Lawrence may be increased, and the depth in Montreal Harbor as well as in the ship channel below Montreal may also be increased during the low water season. The extent of the improvement in the low water flow is variously estimated at from 15,000 to 25,000 cubic feet per second. The additional depth provided during the low water months at Montreal is also variously estimated at from about 3 inches to over 1 foot, and that proceeding downstream in the ship channel, this effect gradually diminishes. The commission is of the opinion that a material improvement in the existing conditions may be anticipated, the exact degree of which can only be determined after practical experience has indicated the best scheme of regulation to adopt; and that this improvement can be secured at no additional cost.

Ice conditions.—This very important question is discussed not only in the report of the engineering board but also in those of the Hydro-Electric Power Commission of Ontario, the New York & Ontario Power Co., and Hugh L. Cooper & Co. It was also gone into at considerable length by the various engineers who appeared before the commission at the Ottawa hearing on November 14–15, 1921.

The ice question in connection with such a river as the St. Lawrence, with its immense volume, varying currents, and severe winter

conditions, presents one of the most difficult problems confronting engineers in designing works for its improvement. With the river in its natural condition ice jams have occurred in the past that caused immense damage, and with the introduction of artificial works, unless these are very carefully located and designed, the opportunities for ice trouble are accentuated.

It is anticipated that the works recommended will have the effect of greatly reducing the formation of anchor and frazil ice in the critical section of the river from the upper end of Lake St. Francis to the head of the Galops Rapids. Nevertheless the solution of this ice problem is so vital to the success of the proposed improvement that the commission is strongly of the opinion that it should be gone into very thoroughly by the larger board elsewhere recommended.

Alternative schemes.—Under the terms of the reference the commission is required to answer the question, "Which of the schemes submitted by the Government or other engineers is preferred, and why?" In compliance with the spirit of these instructions the commission has considered a number of alternative suggestions, proposing either modifications in the plans of the Board of Engineers or entirely new plans. Most of these alternative plans, it may be noted, are prepared rather from the point of view of water power development than from that of navigation. They have been submitted by or on behalf of the Hydro-Electric Power Commission of Ontario, the New York & Ontario Power Co., Hugh L. Cooper & Co., and Mr. E. S. M. Lovelace of Montreal.

Taking them in the order mentioned, they may be briefly summarized as follows:

The Hydro-Electric Power Commission of Ontario submit three alternative schemes, designated A, B, and C, respectively. Scheme A is a single-head development, very similar to that recommended by the engineering board. It would concentrate the entire available fall at the foot of the Long Sault Rapids, where the main dams and power houses would be situated. There would also be a control dam at the Rapide Plat to regulate the outflow from Lake Ontario. The normal operating head of the proposed power house would be 74.5 feet. At the head of the South Sault channel there would be a power house to utilize, under a head of about 28 feet, that part of the flow of the river diverted to the power house at Massena, N. Y. The total development would produce about 1,492,000 continuous electrical horsepower at a cost of $141,696,192.

Under scheme B the development would be carried out in two stages, the upper of which would include the fall in the Galops rapids and the Rapide Plat, while the lower would include the fall in the vicinity of Farrans Point and at the Long Sault Rapids. This scheme therefore involves a double head development. Two power houses would be built extending from the east end of Ogden Island to Clark Island and thence to Murphys Point. These would utilize the head of 27 feet created by the proposed Ogden Island dam. The locations of the dams at the Long Sault in this scheme are the same as in scheme A; and also the power houses on Barnhart Island are in very nearly the same situation. The head to be developed at these power houses, however, is only 53.5 feet. The total development would produce about 1,600,000 continuous electrical horsepower at a cost of $154,092,512.

Scheme C, also a double-head development, is a modification of scheme B. The upper dam and power house would be placed at Crysler Island and the lower power house at Barnhart Island. The total development would produce about 1,635,000 continuous electrical horsepower at a cost of $154,925,415.

Under scheme A about 29,000 acres of valuable settled land would be flooded, including several small towns and hamlets. Under scheme B about 6,000 acres would be flooded.

In addition to excavation and other improvements at various points in the river channel, scheme A provides a lock immediately below the old dam at Waddington, a canal from the head of Sheik Island to Cornwall, with a pair of guard gates half a mile below the entrance, a lock opposite Moulinette, a canal reach 6 miles long from opposite Moulinette to Cornwall, a second lock located at Cornwall, where a junction is made with the St. Lawrence River a short distance west of the lower entrance of the Cornwall Canal. Under scheme B, a dam and lock would be required a short distance above Morrisburg and also a series of dams at the Long Sault Rapids with a short side canal from Dickinsons Landing to a junction with the river at Cornwall. This canal would have a pair of guard gates with supply weir and two locks, one east of Maple Grove and one at Cornwall.

Under scheme C the provision for navigation would be the same as under scheme B from Cornwall to Dickinsons Landing, but the dam and lock above Morrisburg would be eliminated, and a dam and lock would be required near Crysler Island. All locks would be constructed to provide for a draft of 30 feet, with a length of 860 feet and width of 80 feet. Canal reaches to have a depth of 25 feet.

The estimated cost of scheme A is $209,843,804, of which $141,696,192 is charged to power and $68,147,612 to navigation. The estimated cost of scheme B is $211,466,419, of which $154,092,512 is charged to power and $57,373,907 to navigation. The estimated cost of scheme C is $214,881,524, of which $154,925,415 is charged to power and $59,956,109 to navigation.

The Hydro-Electric Power Commission describes each of these schemes in detail, and points out certain advantages and disadvantages believed to be inherent in each. Nevertheless it is of the opinion that "the engineering factors involved appear to demonstrate that from the standpoint of adequacy and capital costs there is little to choose between the single stage and double stage developments," and it refrains from pronouncing in favor of any of the three schemes.

The New York & Ontario Power Co. proposes a double development scheme, with dams at the foot of the Rapide Plat and at the Long Sault Rapids. The project would include power houses at Barnhart Island and another power house at Morrisburg. At Morrisburg there would be a canal and lock on the Canadian side, and at the Long Sault there would be a canal from Mille Roche to Cornwall with guard gates and locks in the same location as shown in the Report of the Hydro-Electric Power Commission. The dimensions of locks and canals would be substantially the same as in the plans of the engineering board. This double development scheme would, it is estimated, produce 1,655,000 primary horsepower at a

cost of $143,350,598, of which $103,893,525 is charged to power and $39,457,073 to navigation.

The plans of Hugh L. Cooper & Co. contemplate the improvement of the St. Lawrence for navigation and power by means of five dams, the first of which they would locate at Cat Island, 24 miles below the Galops Rapids. The five dams are expected to develop a total operating head of about 196 feet.

Cooper & Co. propose to build the dam and power plant at Cat Island and put it into operation before proceeding with the construction of the other dams and power developments downstream. They estimate that 1,000,000 horsepower would be available at this site.

The estimated cost of the Cat Island improvement is about $200,000,000. The estimated cost of the entire improvement of the St. Lawrence between Lake Ontario and Montreal for the development of 6,625,000 horsepower is stated to be $1,450,000,000, of which $1,300,000,000 is charged to water power and $150,000,000 to navigation.

It is apparent that Col. Cooper's scheme is primarily for the development of power; and that it contemplates a single development at Cat Island, leaving the four plants below Cat Island for future construction, presumably when the power developed at the Cat Island plant has been marketed. No particulars are furnished in regard to any of the developments except that at Cat Island, and no detailed estimates even for the Cat Island plan.

Mr. Lovelace, beyond expressing his personal view that the improvement of the natural channel of the river is preferable to the canals recommended by the engineering board, has very little to say as to the merits of the scheme. His personal interest is in the improvement of conditions in the harbor of Montreal, for which he advocates a submerged dam in the vicinity of Varennes, below Montreal, to raise the water in the harbor some 10 or 12 feet. This, he says, would drown out the St. Mary current and incidentally make it unnecessary to provide the lock recommended by the engineering board immediately below Victoria Bridge. Mr. Lovelace is also of the opinion that if his proposed dam were adopted it would make possible a different, and he believes a preferable, route for the waterway from that proposed by the engineering board between Montreal and Lake St. Louis.

It will be noted that the plans submitted by the Hydro-Electric Power Commission and the New York & Ontario Power Co. are confined to the international section of the river; that Col. Cooper's plan deals with a single development in the same section of the river; and that Mr. Lovelace's suggestions are confined to that portion of the river between Montreal and Lake St. Louis. It is apparent, therefore, that none of these plans and suggestions provide for a complete scheme of development from Lake Ontario to Montreal, as required by the terms of the reference.

The commission has had the advantage not only of studying the above reports as submitted but also of hearing them discussed by the various engineers at the hearings in Ottawa on November 14 and 15. The commission listened with interest to the comparison of the alternative plans with that of the engineering board, and the respective

advantages and disadvantages of each as seen by different engineers, and was particularly impressed with the fact that the points of disagreement were all on comparatively minor features of the problem.

Without the expert assistance of technical advisers, the commission could not attempt to make any authoritative decision between the plans of the engineering board and the alternative plans submitted, in so far as they are comparable; and even if the commission had such technical advisers at its disposal, it is evident that they would have to give several months to a very careful study in detail of the various schemes before a conclusion could be reached. Under all the circumstances, and as the commission was asked by the two Governments to file its report within three months of the receipt of the report of the engineering board, the commission has decided to accept the plans of the engineering board as a basis for the recommended improvement of the St. Lawrence, with the suggestion as already outlined that both the plans of the engineering board and the alternative plans should be referred to a larger board for final determination.

WATER POWER.

The terms of the reference make it clear, in the opinion of the commission, that the intention of the two Governments was that the proposed improvement of the upper St. Lawrence should serve primarily the interests of navigation and commerce and only incidentally those of water power. The first and principal question reads: "What further improvement in the St. Lawrence River, between Montreal and Lake Ontario, is necessary to make the same navigable for deep draft vessels of either the lake or ocean-going type; what draft of water is recommended; and what is the estimated cost?" And in answering this question, the commission is requested to consider two alternative schemes, one providing for navigation interests alone, and the other for a combination of navigation and power interests "to obtain the greatest beneficial use of the waters of the river."

Obviously the first consideration is to take care of the interests of navigation, and water power is only to be considered in so far as its development is not inconsistent with the primary interests of navigation. Under the terms of the treaty of January 11, 1909, the interests of navigation are given precedence over those of power in all cases involving the use or obstruction or diversion of boundary waters between the United States and Canada, or of waters flowing from boundary waters or at a lower level than the boundary in rivers flowing across the boundary, and "no use shall be permitted which tends materially to conflict with or restrain any other use which is given preference over it" in order of precedence. In carrying out the investigation, the commission has recognized this order of precedence. Fortunately, it has been possible to do so without doing violence to either interest, as the scheme recommended, that is a combination of navigation and power in the international section of the river, does, in the opinion of the commission, secure the maximum efficiency from the waters of the St. Lawrence both for navigation and water power.

In regard to the electrification of railways, there is much force in the argument that, given a sufficient and conveniently located supply of power at a reasonable cost, railways would be transformed from steam to electricity, but it must not be lost sight of that other factors enter into the problem, particularly the capital cost of the proposed change. The capital cost would be so great that electrification could only be justified by exceptional traffic conditions, such, for instance, as those found in a densely populated area, or involving heavy grades as in the Rocky Mountains, or, as suggested above, by the availability of cheap electric power. In any event the question is one for the railway companies, who are the best judges as to the circumstances under which electrification would be economically a sound policy, and while the commission believes that ultimately electrification will be applied to all the principal railway lines, there does not appear to be any immediate prospect of a movement in that direction on the part of railways that might be served with power from the St. Lawrence.

At the same time, the commission can not lose sight of the fact that the present project, if the Governments decide to go on with it, can hardly be completed inside of ten years, and he would be a rash prophet who ventured to put limits to the possible developments in the use of hydroelectric power during the next two decades; either in the direction of electrification of railroads, or still more in the building up of such great basic industries as have followed a similar development of power from the Niagara.

The commission is of the opinion that in so far as markets are likely to be available for St. Lawrence power within a reasonable period after the St. Lawrence improvements have been completed, the situation is substantially as follows:

As appears from what has been said in Part V, those who have given particular attention to this matter, both in the United States and Canada, are for the most part of the opinion that markets will be available to absorb all the power that can be developed on the international section of the St. Lawrence within a reasonable period after the completion of the proposed works. The commission has before it graphs Nos. 3 and 5 showing the present use of power on both sides of the boundary within a radius of approximately 300 miles of the Long Sault Rapids, and also the probable future demand. It appears from these graphs that at the present time (1921) the total primary power installation on the United States side of the 300-mile area is approximately 9,900,000 horsepower and on the Canadian side 1,900,000 horsepower. The estimated demand on the United States side in 1925 is 11,000,000 horsepower and on the Canadian side 2,350,000 horsepower; and in 1930, on the United States side 12,500,000 horsepower and on the Canadian side 2,875,000 horsepower.

It will be noted that the Director of the United States Geological Survey is of the opinion that "the demand in New York and New England would take care of all the power that might be developed on the St. Lawrence as soon as it was made available," and that this opinion is confirmed by the report on the proposed superpower system. Evidence as to the demand on the Canadian side of the area goes to show that ultimately Canada will be in a position to

use her share of the available power on the international section of the St. Lawrence, although obviously for some years after the works are completed there will be a much greater demand for power by the United States than by Canada.

SUMMARY OF CONCLUSIONS.

To sum up as briefly as possible its conclusions in the matter of the proposed improvement of the St. Lawrence River between Lake Ontario and Montreal, the commission finds nothing in the evidence to warrant the belief that ocean-going vessels of suitable draft could not safely navigate the waters in question as well as the entire waterway from the Gulf of St. Lawrence to the head of the Great Lakes, or that such vessels would hesitate to do so if cargoes were available.

It finds that of the various alternative routes mentioned from the interior to the seaboard, none offers advantages comparable with those of the natural route by way of the St. Lawrence.

As to the economic practicability of the waterway, the commission finds that, without considering the probability of new traffic created by the opening of a water route to the seaboard, there exists to-day, between the region economically tributary to the Great Lakes and overseas points as well as between the same region and the Atlantic and Pacific seaboards, a volume of outbound and inbound trade that might reasonably be expected to seek this route sufficient to justify the expense involved in its improvement.

It finds that, as between the American and Canadian sides of the tributary area, the former contributes very much the larger share of this foreign and coastwise trade, and in all probability will continue to do so for many years to come. The benefits to be derived from the opening of a water route to the sea will therefore accrue in much larger measure to American than to Canadian interests, though it is reasonable to assume that eventually the advantages may be more evenly distributed.

It finds that the existing means of transportation between the tributary area in the United States and the seaboard are altogether inadequate, that the railroads have not kept pace with the needs of the country, but that this does not apply to the Canadian side of the area, where railway development is still in advance of population and production.

While the commission is conscious of the fact that war conditions had something to do with the dislocation of railway traffic on the United States side of the boundary, and that various other factors must be taken into account, such as the congestion of traffic at certain critical points between the West and the Atlantic seaboard commonly referred to as "bottle-necks," and the abnormal demand for cars at certain times of the year to carry the peak load of the harvest, it is convinced that the fundamental difficulty lies rather in the phenomenal growth of population and industry throughout the middle western and western States, a growth which the railroads have failed to keep pace with.

The solution of the problem, in the opinion of the commission, lies in the utilization of every practicable means of communication, and particularly of the wonderful natural waterway extending from the

Atlantic into the very heart of the continent, together with the development of such a system of cooperation between railways and waterways as would at one and the same time bring the load the railways have to carry within practicable limits, and give the West an additional route for its foreign and coastwise trade.

Experience has demonstrated not only the tremendous importance of water communication to the foreign commerce of any country but also the manifest advantages of linking up rail and water routes. It is beyond question that the phenomenal industrial development of Great Britain in modern times has been due very largely to her ready access to the sea. Great Britain has no resources of iron, yet she has built up gigantic steel industries; she grows no cotton, yet she supplies half the world with cotton goods; she produces very little wool, yet her woolen mills have developed into an enormous industry. Her merchant marine sail the seven seas, bringing to her shores the raw materials she needs for her industries, and carrying back the finished products. The sea, that most efficient, most adaptable, most far-reaching, most economical of thoroughfares, possessing practically all the advantages of land transportation with few of its disadvantages, has made Great Britain prosperous.

And what water transportation has done for Great Britain it has done in greater or less degree for other nations in other times. Access to the sea gave the diminutive Republic of Venice preeminence in the Mediterranean. It transformed little Holland from a comparatively obscure province into a great maritime nation. It gave to Spain her period of greatness. It brought Germany before the war within almost measurable distance of supremacy in the foreign trade of the world.

The conclusion is obvious that, if countries that had for the most part to import their raw materials from abroad were able to build up a great foreign trade because of their ready access to the sea, the region economically tributary to the Great Lakes, with its limitless resources, its raw materials within easy reach, its facilities for industrial expansion, can hardly fail to become an even greater factor in the world's markets than it is to-day, if given a practicable and efficient water route to the sea.

Of scarcely less importance is the linking up of land and water routes. Here also the experience of Europe is illuminating. Belgium and England are the most densely populated portions of Europe, and both are preeminently industrial nations. Each possesses a network of railways reaching into every corner of the country, yet each is to-day, despite its very short rail haul to tidewater, finding it necessary, in order to give adequate service to congested areas, to link up the railways and the highways with the inland waterways. Despite the difference in area between these countries and the region tributary to the Great Lakes, transportation conditions are not altogether dissimilar, particularly in the more congested areas of the Middle West. One finds in such a district as that around the south shore of Lake Michigan much the same conditions of a rapidly increasing concentration of population and industry, with a corresponding concentration of rail lines, that is so noticeable in England and Belgium. And similar conditions are quite evidently developing in the territory immediately tributary to

Detroit, Cleveland, and other middle-western cities. When these cities and their tributary territory are given access to the sea, they will find it necessary, in order to secure the maximum benefits from the new route, to coordinate their railways and highways with the great waterway that will be common to them all. The advantages of cooperation will be found as real in this case as in Europe, although the remedy may be somewhat different in character.

An example on this continent of the effective coordination of rail and water services is found in the Canadian Pacific Railway, which, in conjunction with its rail system extending from ocean to ocean, maintains lines of steamers not only on the Atlantic and the Pacific but also on the Great Lakes and the inland waters of British Columbia.

The whole question of the distribution of cost has given the commission some concern. If the area to be benefited were all in one country the problem of financing the improvement would be a comparatively simple one, but as the matter stands the situation is complicated not merely by the fact that two neighboring countries are joining in the project, but that these countries are unequal in population, unequal in wealth, unequal in their ability to make effective use of the waterway. That is the situation to-day, but it does not necessarily follow that it will always be the situation. As the years go by the relative position of the two countries will doubtless change, and the disproportion between their population, wealth, and commerce may gradually diminish. In the meantime the fair and reasonable plan appears to be to divide the cost in proportion to the benefits each receives.

Objection may be made that the proposed principle of dividing the cost in proportion to the benefits each country derives from the improvement could hardly be put into effect until the works had been completed and in operation for a sufficient period to secure reliable data on the subject. For the intervening period, however, the commission believes that there are already available authoritative statistics on which to base a tentative decision as to the interest each country is likely to have in the waterway.

Another factor in the situation that should not be lost sight of is the peculiar relationship to the proposed improvement of the New Welland Ship Canal, a portion of which is now under construction. As pointed out in an earlier part of this report, the completion of the Welland Ship Canal and the adoption and completion of the St. Lawrence improvement would remove the only barrier to the creation of a deep-water route from the head of the lakes to the sea. This would give at least 25-foot navigation from the sea up to the Detroit River, with a present minimum of about 20 feet above Lake Erie. Although entirely outside the strict terms of the reference submitted to it by the two Governments, the commission has been impressed by the fact that the New Welland Ship Canal is such an integral part of the waterway, and is so inseparably interwoven with the project under immediate consideration, that it should properly be considered as a part of the whole scheme and the expense of its construction should be apportioned between the two Governments upon the same basis as the works recommended for the upper St. Lawrence.

In other words, each country should be debited with its share of the entire cost of all works necessary for navigation, including the

cost of the Welland Ship Canal, based upon the proportion the cargo tonnage carried to and from its own ports by way of the St. Lawrence bears to the entire tonnage by the same route. The ratio to be charged to each obviously would require to be readjusted periodically.

In regard to the water power side of the question, by the language of the treaty as well as the obvious intention of the reference, water power must be regarded as subsidiary to navigation. Statements were repeatedly made during the hearings to the effect that while the movement for improving the St. Lawrence was nominally in the interests of navigation, it was really being engineered by water power interests to serve their own ends. The commission is confident that there is no justification whatever for these assertions. As a matter of fact, as already stated, very little testimony of any kind was offered at the hearings upon the power side of the question, public attention being apparently centered on the economic practicability of the undertaking as a navigation route.

For the purposes of the conclusions, recommendations, and answers to questions, "navigation works" shall be deemed to mean and include all works of every kind and description required for the proposed improvement of the St. Lawrence between Montreal and Lake Ontario other than and except superstructures, machinery, plant, and equipment for the development and utilization of power in connection with such improvement; and "power works" shall be deemed to mean and include all superstructures and all machinery, plant, and equipment required for the development and utilization of power in connection with the said improvement.

In apportioning between the two countries the water power capable of development in the international section of the St. Lawrence, each country should be charged with such quantities of power as are set apart to meet the requirements of existing plants.

In regard to the distribution between the two countries of the cost of "power works," the commission is of the opinion that as each country will be entitled to half the available power in the international section of the river, the cost of the works necessary solely for the development of that power should be borne equally by each country. It is further of the opinion that the cost of "navigation works" required for the combined use of navigation and power over and above the cost of works necessary for navigation alone should be apportioned equally between the two countries.

As elsewhere noted, it was repeatedly stated by those who appeared before the commission that the water power developed on the St. Lawrence would be sufficiently valuable to carry a considerable proportion, if not the whole, of the cost of the undertaking both for navigation and power. The commission desires to emphasize the point that if this prediction should prove well founded, nothing in the commission's conclusions and recommendations as embodied in this report need conflict with the charging to water power by either country of any proportion of its share of the entire cost that may eventually be found desirable.

In regard to the method of control, the commission is conscious of the fact that the peculiar character of the St. Lawrence, partly international and partly national, creates an unusual situation, and

it believes that, in order to combine the fullest possible liberty of action on the part of each country in its own territory, with the efficient coordination of the several parts of the completed improvement, all "navigation works" lying wholly within one country and capable of economic and efficient administration as complete and independent units, should be maintained and operated by the country in which they are located; that "navigation works" not lying wholly within one country and not capable of economic and efficient administration as complete and independent units, should be maintained and operated by an international board on which each country would have equal representation; and that this board should also have the right of inspection of "navigation works" lying wholly within one country, for the purpose of insuring economy and efficiency. The commission is further of the opinion that all "power works" should be built, maintained, and operated by the country in which they are located.

An important result of the proposed improvement, if carried out, will be the extent of damage resulting from flowage due to the higher levels maintained in the St. Lawrence. This damage is estimated by the engineering board at about $6,000,000. The commission is of the opinion that there should be an exhaustive investigation of the extent and character of the damage as soon as the plan of development has been finally accepted.

Finally, the commission is strongly of the opinion that the subject matter of this investigation is one of such extraordinary importance to the people of the two countries, and involves engineering problems of such magnitude and diversity, that no effort should be spared to secure a plan which will beyond all reasonable doubt obtain from the upper St. Lawrence its maximum efficiency in navigation and power. To this end the commission believes that, before any particular scheme is finally adopted, all the available engineering data, including the report and plans of the engineering board and all comments thereon or alternative plans, should be referred to a special technical board for careful consideration and report.

RECOMMENDATIONS.

In harmony with its conclusions as outlined in the foregoing report the commission recommends:

(1) That the Governments of the United States and Canada enter into an arrangement by way of treaty for a scheme of improvement of the St. Lawrence River between Montreal and Lake Ontario.

(2) That the New Welland Ship Canal be embodied in said scheme and treated as a part thereof.

(3) That the proposed works between Montreal and Lake Ontario be based upon the report of the engineering board accompanying this report, but that before any final decision is reached the report of the board, together with such comments, criticisms, and alternative plans as have been filed with the commission be referred back to the board enlarged by other leading members of the engineering profession, to the end that the whole question be given that further and complete study that its magnitude and importance de-

mand, and that after completion the administrative features of the improvement be carried out as set forth in recommendations 7 and 8 hereof.

(4) That there shall be an exhaustive investigation of the extent and character of the damage through flowage involved in the plan of development finally adopted.

(5) That, assuming the adoption of the plans of the engineering board, or of other plans also involving a readjustment of the international boundary, in order to bring each of the power houses on its own side of the boundary, appropriate steps be taken to transfer to one country or the other, as the case may be, the slight acreage of submerged land involved.

(6) That Canada proceed with the works necessary for the completion of said New Welland Ship Canal in accordance with the plans already decided upon by that country.

(7) That such "navigation works" as do not lie wholly within one country or are not capable of economic and efficient construction, maintenance, and operation within one country as complete and independent units, be maintained and operated by a board hereinafter called "the International Board," on which each country shall have equal representation.

(8) That such "navigation works" as lie wholly within one country and are capable of economic and efficient construction, maintenance, and operation as complete and independent units be maintained and operated by the country in which they are located with the right of inspection by the said international board to insure economy and efficiency.

(9) That "power works" be built, installed, and operated by and at the expense of the country in which they are located.

(10) That, except as set forth in recommendation (11), the cost of all "navigation works" be apportioned between the two countries on the basis of the benefits each will receive from the new waterway: *Provided*, That during the period ending five years after completion of the works—and to be known as the Construction Period—the ratio fixing the amount chargeable to each country shall be determined upon certain known factors, such as the developed resources and foreign and coastwise trade of each country within the territory economically tributary to the proposed waterway, and that that ratio shall be adjusted every five years thereafter and based upon the freight tonnage of each country actually using the waterway during the previous five-year period.

(11) That the cost of "navigation works" for the combined use of navigation and power over and above the cost of works necessary for navigation alone should be apportioned equally between the two countries.

ANSWER TO QUESTIONS.

Finally, coming to the specific questions submitted to the commission by the two Governments, the commission does not deem it necessary to make any extended answers in view of the conclusions and recommendations set forth in the foregoing pages. The commission answers the several questions as follows:

Question I. What further improvement in the St. Lawrence River, between Montreal and Lake Ontario, is necessary to make the same navigable for deep draft vessels of either the lake or ocean-going type; what draft of water is recommended; and what is the estimated cost?

In answering this question, the commission is requested to consider:

(*a*) Navigation interests alone, whether by the construction of locks and dams in the river; by side canals with the necessary locks; or by a combination of the two.

(*b*) The combination of navigation and power interests to obtain the greatest beneficial use of the waters of the river.

Answer. (*a*) The commission believes that the greatest beneficial use of the waters of the St. Lawrence River between Montreal and Lake Ontario may be obtained by a combination of navigation and power development in the international section and of navigation alone in the national section with power development therein at some future date.

(*b*) The commission approves of a combination of dams and side canals with locks in the international section, and side canals with locks in the national section, as recommended by the engineering board.

(*c*) The draft of water recommended is 25 feet in the canals and 30 feet on the sills of the locks.

(*d*) The estimated cost of the completed work between Montreal and Lake Ontario as recommended by the engineering board is about $252,000,000. To this must be added the cost of the New Welland Ship Canal in order to ascertain the total expenditure involved.

Question II. Which of the schemes submitted by the Government or other engineers is preferred, and why?

Answer. Of the schemes submitted by the engineering board, the one recommended by them is preferred. Plans and suggestions in connection with certain portions of the river were submitted by other engineers, but the only complete schemes before the commission are those of the engineering board. For reasons already advanced the commission recommends a further examination and study of the plans of the engineering board, when due consideration may be given to the studies and extensive report of the Hydro-Electric Power Commission of Ontario, as well as to the other reports presented to the commission.

Question III. Under what general method of procedure and in what general order shall the various physical and administrative features of the improvement be carried out?

Answer. (*a*) So far as the physical features of the improvement are concerned, the commission believes that the works at and near the Long Sault Rapids, whose completion may be expected to require the greatest amount of time, should be commenced as soon as funds are available; and that all other works, both in the international and national sections of the river, should be commenced in time to insure their completion at approximately the same time as the Long Sault works. This method and order of procedure would at one and the same time secure through deep-water navigation, and make possible the development of power at the earliest practicable date.

(*b*) In regard to the administrative features of the improvement, the commission has set forth in the foregoing recommendations the method of procedure which in its opinion would most efficiently meet the requirements of the situation.

Question IV. Upon what basis shall the capital cost of the completed improvement be apportioned to each country?

Answer. (*a*) The capital cost of "navigation works" and of the New Welland Ship Canal to be apportioned between the two countries on the basis of the benefits to be derived by each country from the use of the waterway.

(*b*) The capital cost of "power works" to be borne by the country in which they are located.

(*c*) The capital cost of "navigation works" for the combined use of navigation and power over and above the cost of works necessary for navigation alone to be apportioned equally between the two countries.

Question V. Upon what basis shall the costs of operation and maintenance be apportioned to each country?

Answer. The apportionment of costs of operation and maintenance of all works both for the purpose of navigation and also of power to be on the same basis as costs of construction of such works respectively.

Question VI. What method of control is recommended for the operation of the improved waterway to secure its most beneficial use?

Answer. The commission recommends: (*a*) That such "navigation works" as do not lie wholly within one country or are not capable of economic and efficient operation within one country as complete and independent units, be operated under the direction of the international board as set forth in recommendation No. 7; (*b*) that all "navigation works" other than those particularly mentioned in (*a*) be operated by the country in which they are located with the right of inspection by the international board as set forth in recommendation No. 8; (*c*) that "power works" be operated by the country in which they are located as set forth in recommendation No. 9.

Question VII. Will regulating Lake Ontario increase the low water flow in the St. Lawrence Ship Channel below Montreal? And if so, to what extent and at what additional cost?

Answer. The commission is of the opinion that regulating Lake Ontario will increase the low water flow in the St. Lawrence Ship Channel below Montreal; but the extent of the increase can only be determined after practical experience has indicated the best scheme of regulation to adopt. This increase in the low water flow will be secured by the works provided in connection with the improvement of the upper St. Lawrence, and consequently at no additional cost.

Question VIII. To what extent will the improvement develop the resources, commerce, and industry of each country?

Answer. The commission has brought together a very considerable volume of data relating to the resources, commerce, and industry of the area that it is believed would be economically tributary to the proposed deep waterway, and has based certain conclusions upon that data, which are embodied in this report. It is impossible to state in more specific terms the extent to which the improvement would develop the resources, commerce, and industry of each country.

Question IX. What traffic, both incoming and outgoing, in kind and quantity, is likely to be carried upon the proposed route both at its inception and in the future, consideration to be given not only to present conditions, but to probable changes therein resulting from the development of industrial activities due to availability of large quantities of hydraulic power?

Answer. To this question also it is impossible to give a specific answer, in the absence of definite information as to all the factors that will enter into the problem. The commission has brought together authoritative information as to the existing traffic between the tributary area and overseas points as well as between the same area and coastwise points on this continent, and has reached the general conclusion that sufficient traffic will seek the new water route, irrespective of new traffic created as the result of the opening of that route, to justify its construction. The commission has so much confidence in the virility and resourcefulness of the people of these two countries that it is convinced the traffic available for the new waterway will rapidly increase with the further development of the area tributary thereto, and that the creation of new hydraulic power in connection with the waterway will stimulate industrial growth both in manufactures and transportation.

O. GARDNER.
C. A. MAGRATH.
C. D. CLARK.
H. A. POWELL.
M. A. SMITH.
W. H. HEARST.

Signed at Washington, this 19th day of December, 1921.

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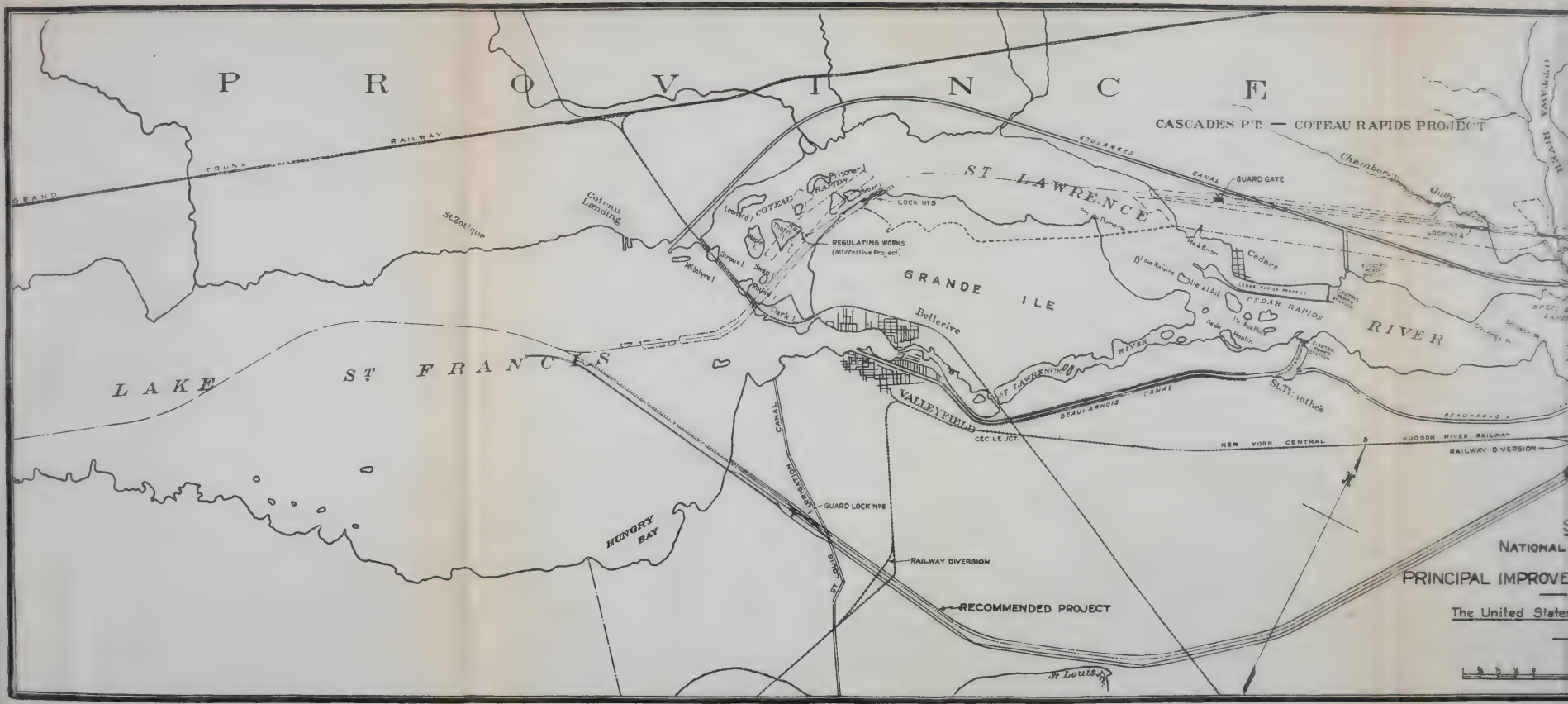

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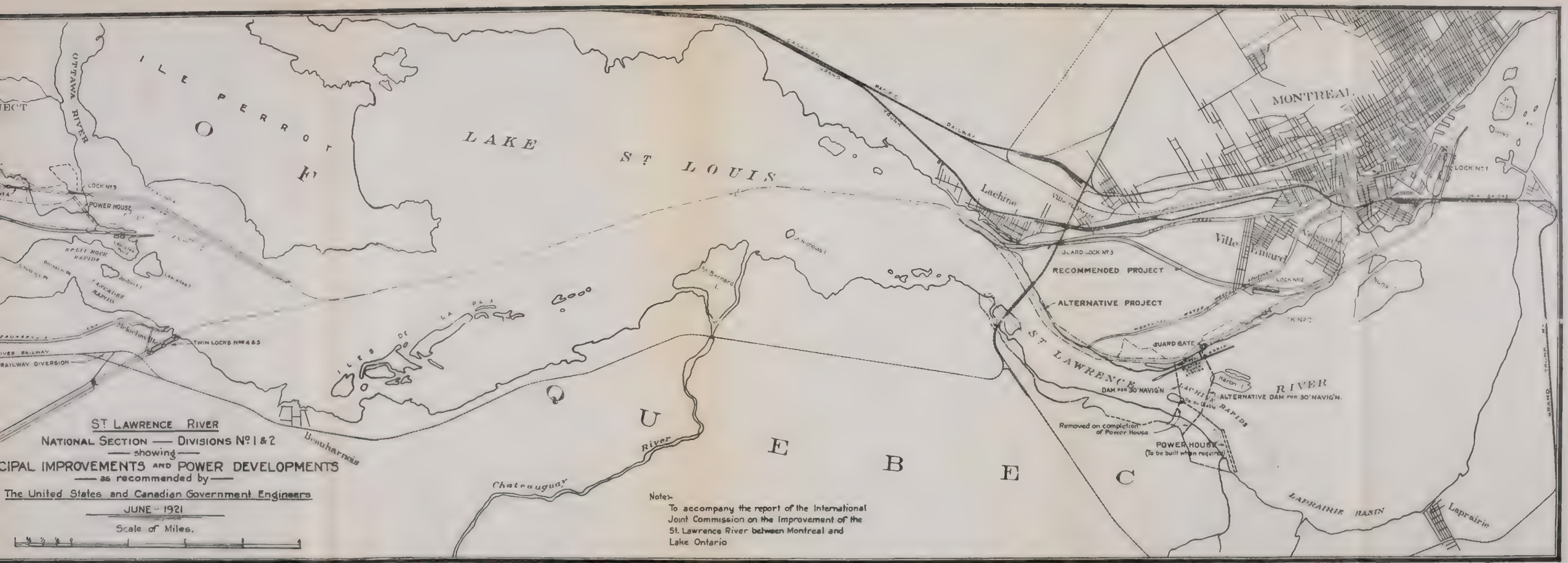


ST LAWRENCE RIVER

NATIONAL SECTION — DIVISIONS No 1 & 2

— showing —

CIPAL IMPROVEMENTS AND POWER DEVELOPMENTS

— as recommended by —

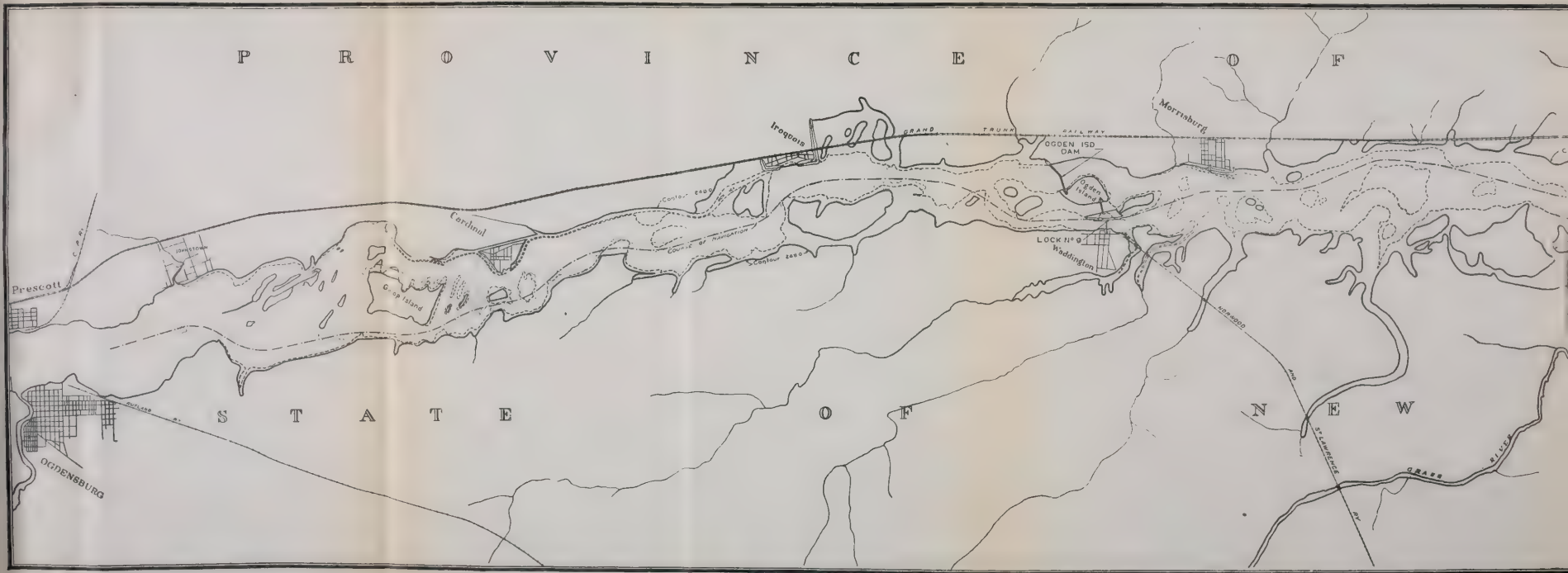
The United States and Canadian Government Engineers

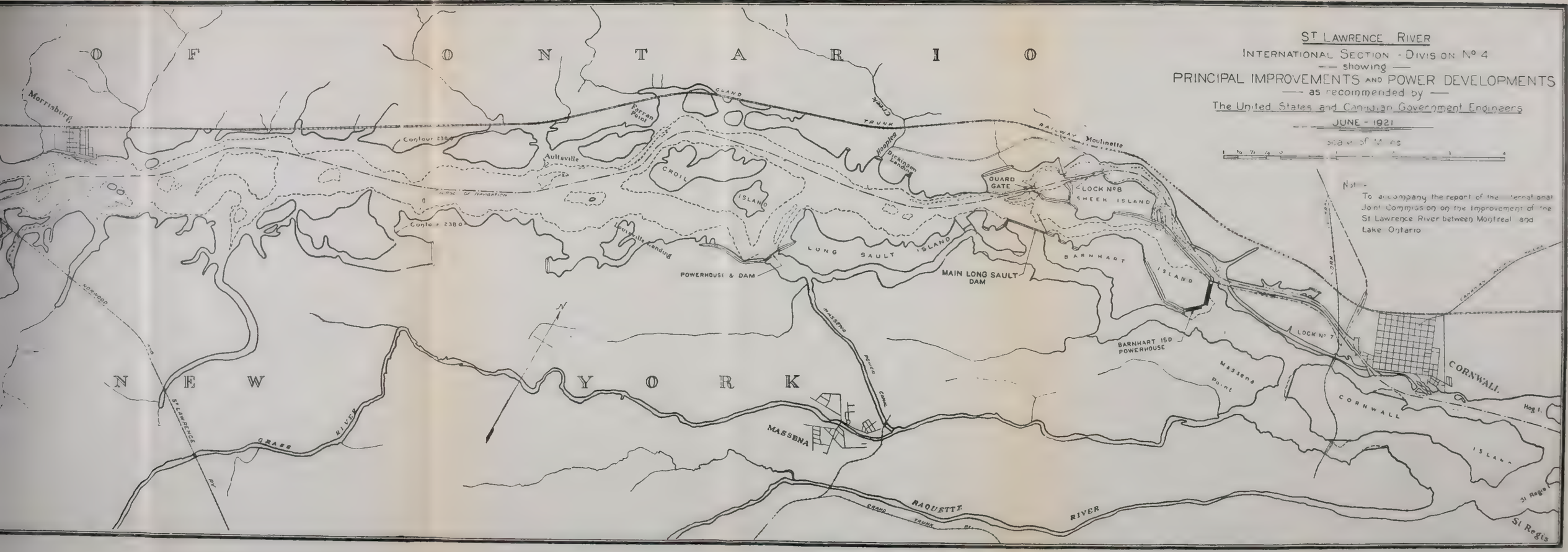
JUNE - 1921

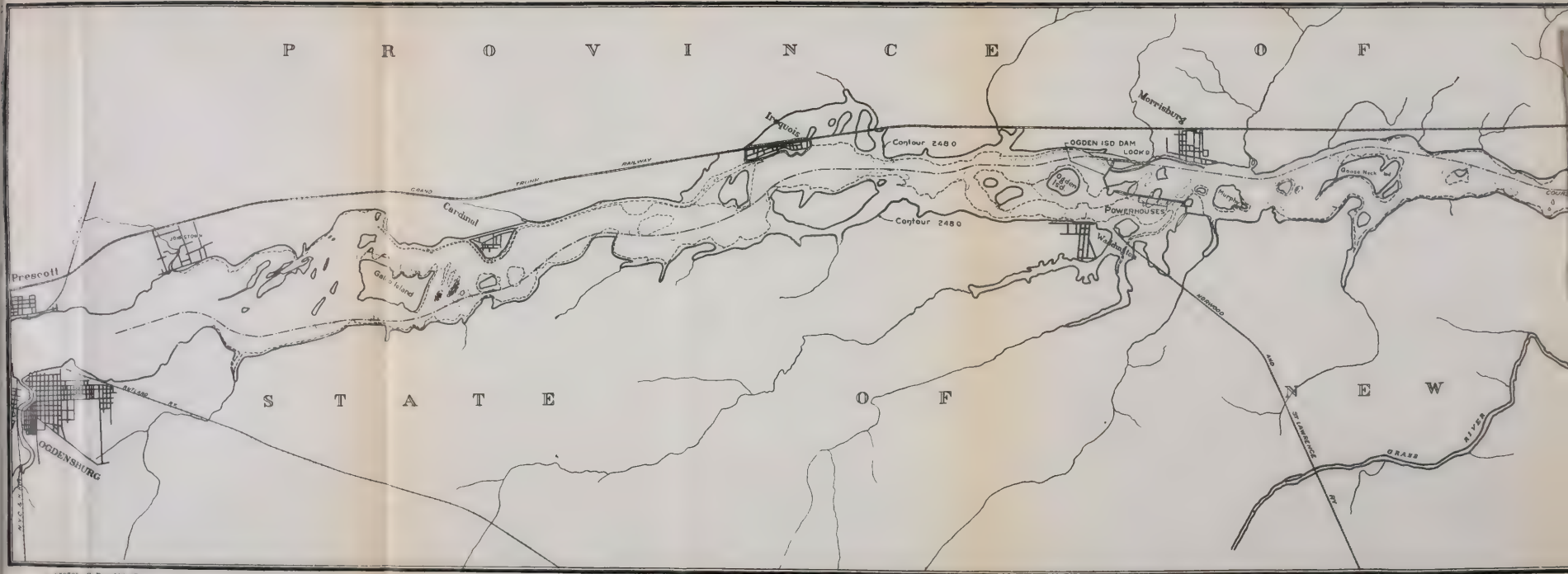
Scale of Miles.

Note:-

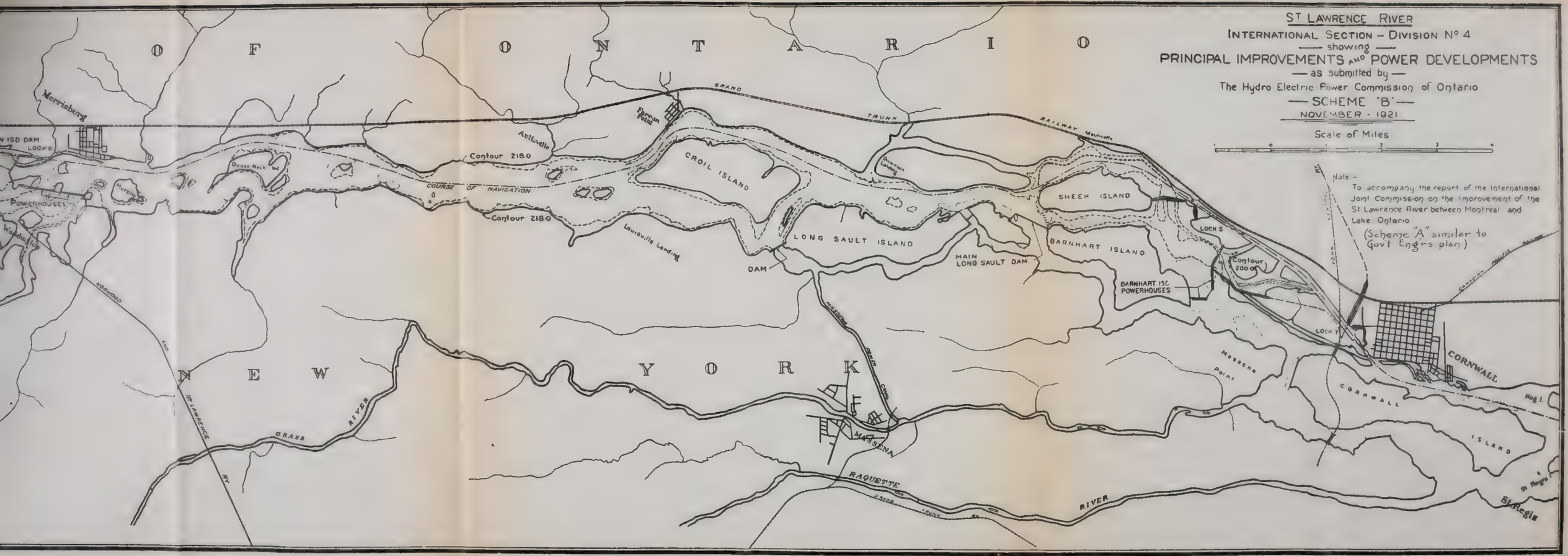
To accompany the report of the International Joint Commission on the Improvement of the St. Lawrence River between Montreal and Lake Ontario

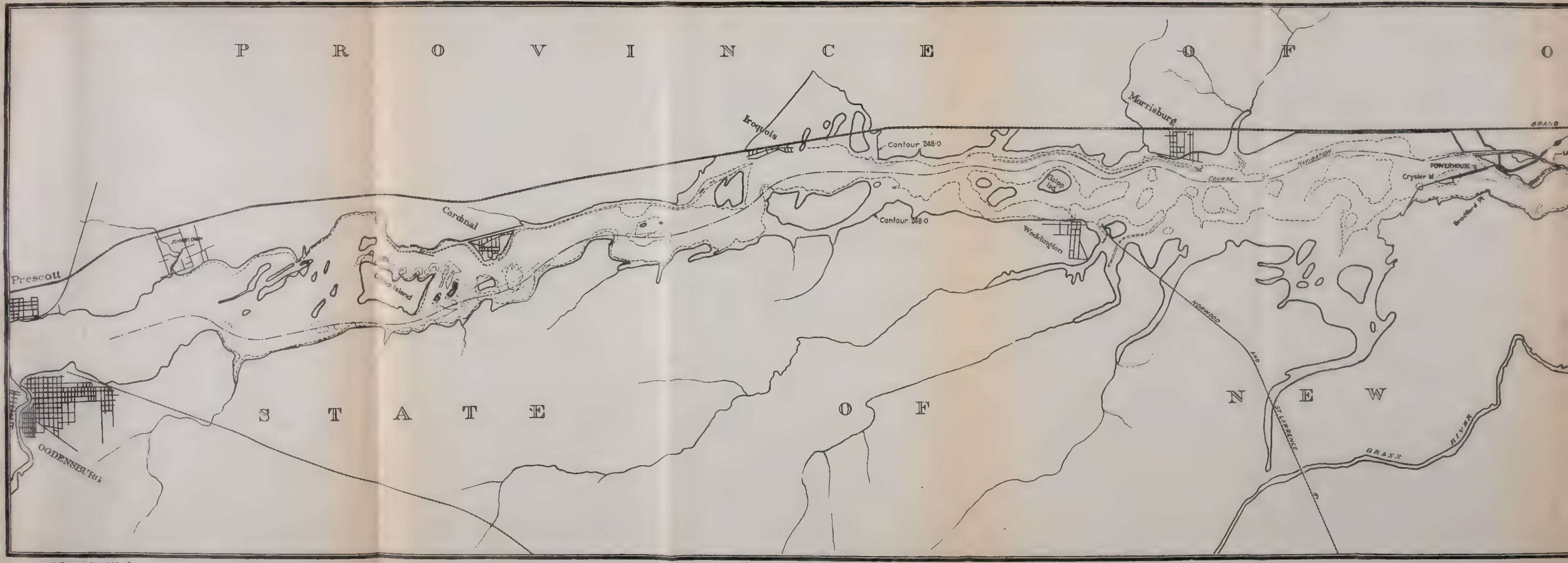

P R O V I N C E O F
Iroquois
GRAND TRUNK RAILWAY
Morrisburg
OGDEN ISD DAM
Ogden Island
Cardinal
Canal
Course of Navigation
LOCK N° 9
Waddington
Prescott
Grenadier Island
S T A T E O F N E W
OGDENSBURG
GRASS RIVER


ST LAWRENCE RIVER
INTERNATIONAL SECTION - DIVISION Nº 4
— showing —
PRINCIPAL IMPROVEMENTS AND POWER DEVELOPMENTS
— as recommended by —
The United States and Canadian Government Engineers
JUNE - 1921
Scale of Miles
Note -
To accompany the report of the International Joint Commission on the Improvement of the St Lawrence River between Montreal and Lake Ontario
ONTARIO
NEW YORK
Morrisburg
Contour 238.0
Aultsville
Croil Island
Dickinson Landing
Moulinette
Guard Gate
Lock Nº 8
Sheek Island
Barnhart Island
Long Sault Island
Powerhouse & Dam
Main Long Sault Dam
Massena Power Canal
Massena
Barnhart Isd Powerhouse
Lock Nº 7
Cornwall
Cornwall Island
Hog I.
St Regis
Raquette River
Grand Trunk R.R.
Grass River
St Lawrence R.R.
Ogdensburg

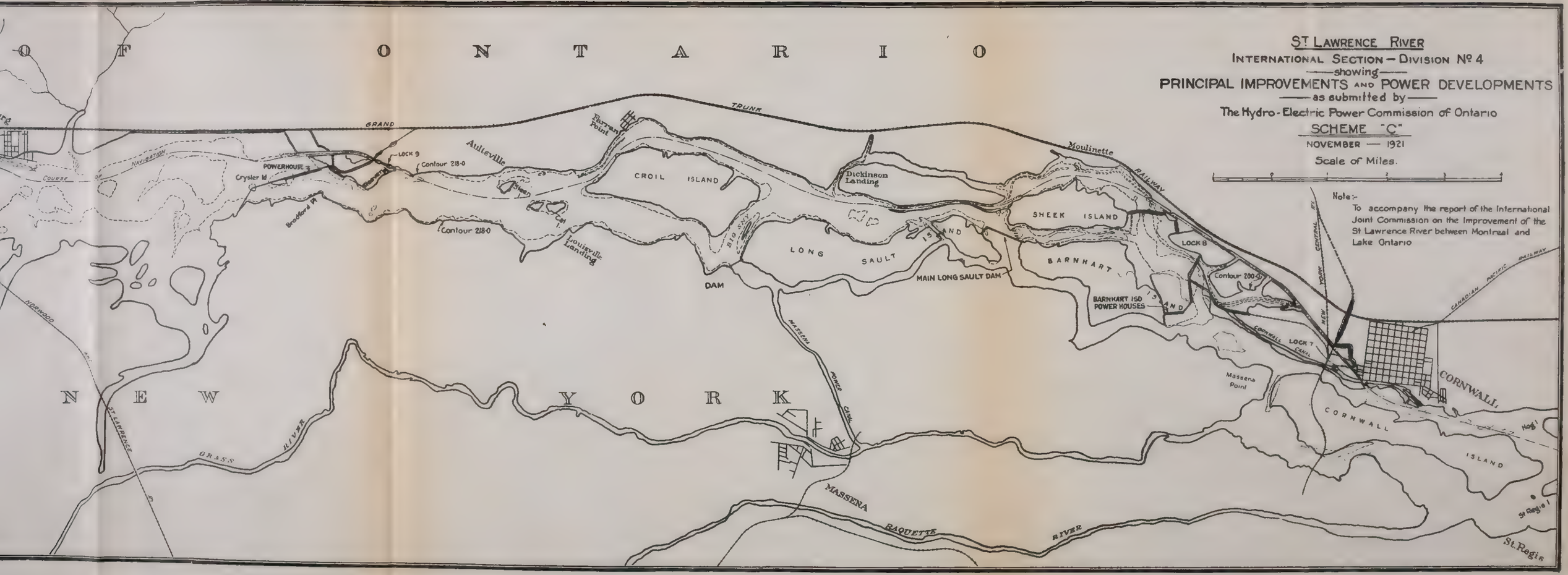


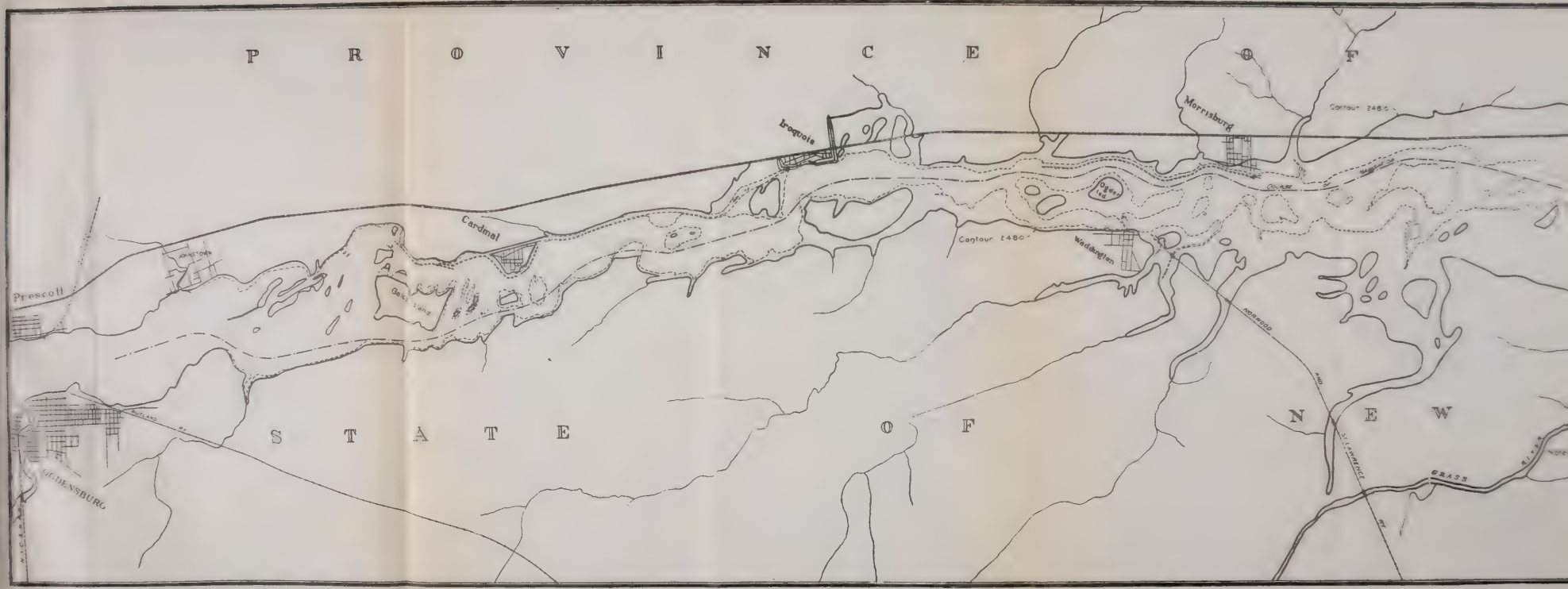
853767—R. Tmr. 114 67-2

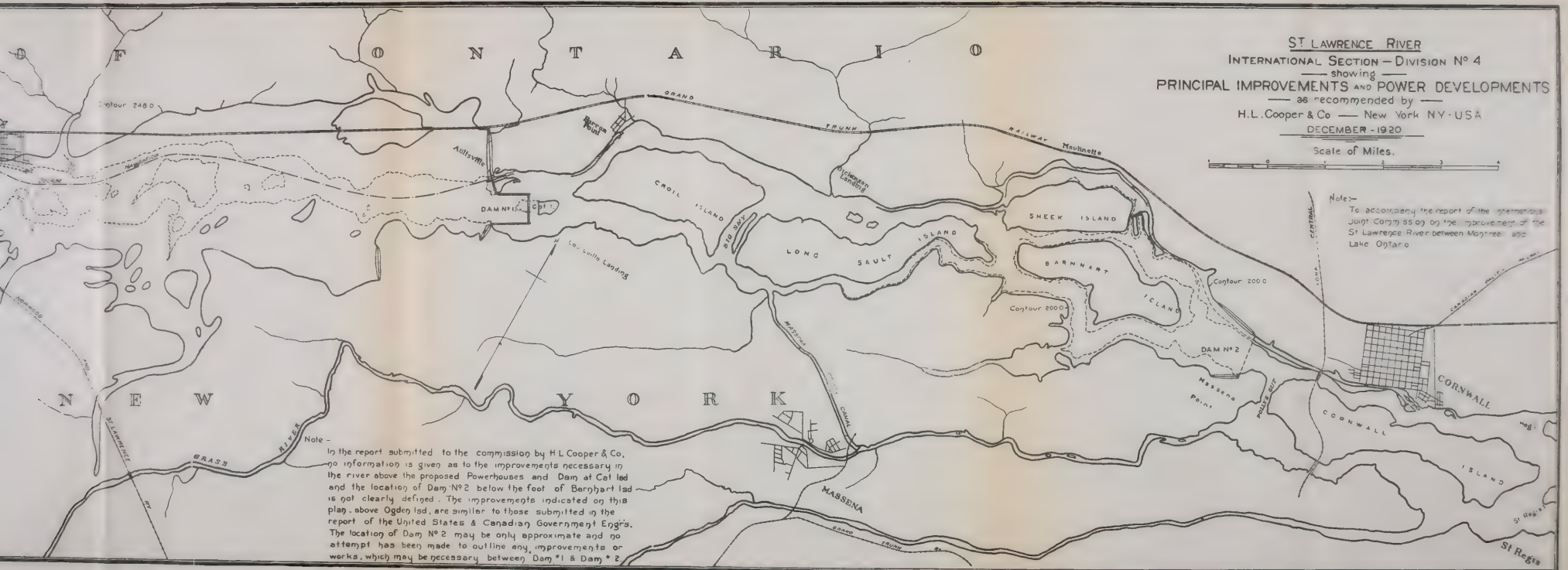

ST LAWRENCE RIVER
INTERNATIONAL SECTION – DIVISION Nº 4
— showing —
PRINCIPAL IMPROVEMENTS AND POWER DEVELOPMENTS
— as submitted by —
The Hydro Electric Power Commission of Ontario
— SCHEME "B" —
NOVEMBER - 1921
Scale of Miles
Note –
To accompany the report of the International Joint Commission on the Improvement of the St Lawrence River between Montreal and Lake Ontario
(Scheme "A" similar to Govt Engrs plan)
O F O N T A R I O
N E W Y O R K
Morrisburg
Dam
Lock 0
Powerhouses
Waddington
Normandale
St Lawrence
Grass River
Aultsville
Contour 218.0
Goose Neck Is
Murphy's
Course of Navigation
Contour 218.0
Louisville Landing
Croil Island
Dam
Long Sault Island
Main Long Sault Dam
Barnhart Island
Barnhart 1st Powerhouses
Locks
Contour 200.0
Sheek Island
Grand Trunk Railway
Massena
Raquette River
Grand Trunk Ry
Massena Point
Lock 7
Cornwall
Cornwall Island
St Regis
St Regis



P R O V I N C E
O F
O
Prescott
Johnstown
Cardinal
Galop Island
Iroquois
Contour 248·0
Contour 248·0
Morrisburg
Ogden Isd.
Waddington
NAVIGATION
COURSE
POWERHOUSE
Crysler Id
Bradford Pt
GRAND
OGDENSBURG
S T A T E
O F
N E W
NORWOOD
AND
ST. LAWRENCE
GRASS
RIVER


ST LAWRENCE RIVER
INTERNATIONAL SECTION — DIVISION Nº 4
showing
PRINCIPAL IMPROVEMENTS AND POWER DEVELOPMENTS
as submitted by
The Hydro-Electric Power Commission of Ontario
SCHEME "C"
NOVEMBER — 1921
Scale of Miles.
0 1 2 3 4
Note:-
To accompany the report of the International Joint Commission on the Improvement of the St Lawrence River between Montreal and Lake Ontario
O N T A R I O
N E W Y O R K
TRUNK
GRAND
NAVIGATION
COURSE OF
POWERHOUSE 3
Crysler Id
Broadford R
LOCK 9
Contour 218-0
Aultsville
Barnes Point
CROIL ISLAND
Dickinson Landing
Moulinette
RAILWAY
SHEEK ISLAND
LOCK 8
Contour 200-0
BARNHART ISLAND
BARNHART ISD POWER HOUSES
MAIN LONG SAULT DAM
LONG SAULT ISLAND
DAM
Louisville Landing
NORWOOD
ST LAWRENCE
GRASS RIVER
MASSENA POWER CANL
Massena Point
CENTRAL
NEW YORK
CANADIAN PACIFIC RAILWAY
CORNWALL CANAL
LOCK 7
CORNWALL
CORNWALL ISLAND
MASSENA
RAQUETTE RIVER
St Regis
St Regis I


P R O V I N C E O F
Morrisburg
Contour 248
Iroquois
Ogden Is.
Cardinal
Contour 248
Waddington
Prescott
Johnstown
Galop Island
S T A T E O F
N E W
OGDENSBURG
GRASS


ST LAWRENCE RIVER
INTERNATIONAL SECTION — DIVISION Nº 4
— showing —
PRINCIPAL IMPROVEMENTS AND POWER DEVELOPMENTS
— as recommended by —
H.L. Cooper & Co — New York NY-USA
DECEMBER - 1920
Scale of Miles.
0
1
2
3
4
Note:-
To accompany the report of the International Joint Commission on the improvement of the St Lawrence River between Montreal and Lake Ontario
ONTARIO
NEW YORK
Contour 248.0
GRAND TRUNK RAILWAY
Moulinette
Ault's ville
DAM Nº 1
Cat I
Dickinson's Landing
CROIL ISLAND
BIG SAUT
LONG SAULT ISLAND
SHEEK ISLAND
BARNHART ISLAND
Contour 200.0
Contour 200.0
Louisville Landing
DAM Nº 2
Massena Point
MASSENA POINT CANAL
MASSENA
GRAND TRUNK
CANADIAN PACIFIC
CENTRAL
CORNWALL
CORNWALL ISLAND
St Regis
ST LAWRENCE RIVER
GRASS RIVER
Note –
In the report submitted to the commission by H.L Cooper & Co, no information is given as to the improvements necessary in the river above the proposed Powerhouses and Dam at Cat Isd and the location of Dam Nº 2 below the foot of Barnhart Isd is not clearly defined. The improvements indicated on this plan, above Ogden Isd, are similar to those submitted in the report of the United States & Canadian Government Engrs. The location of Dam Nº 2 may be only approximate and no attempt has been made to outline any improvements or works, which may be necessary between Dam Nº 1 & Dam Nº 2.

DATE.	NAME OF BORROWER.
May 22/41	Cate. R.
Mar. 13/46	Bridging Dept. (J.R)
Nov 27/51	A. Tucker - 96 Jackman - Grad